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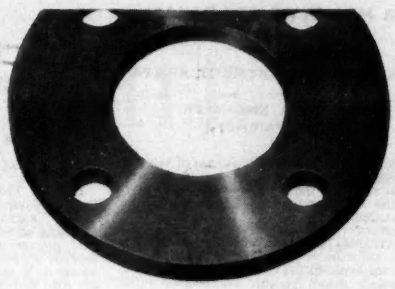

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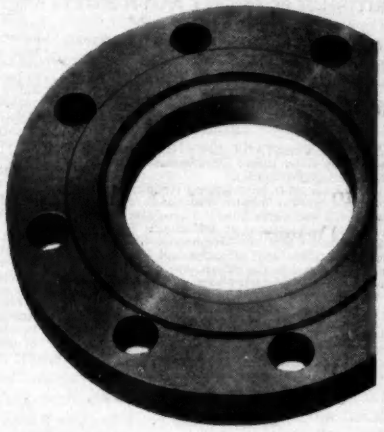

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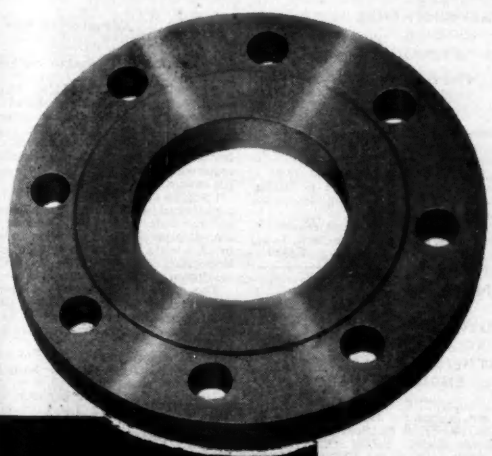

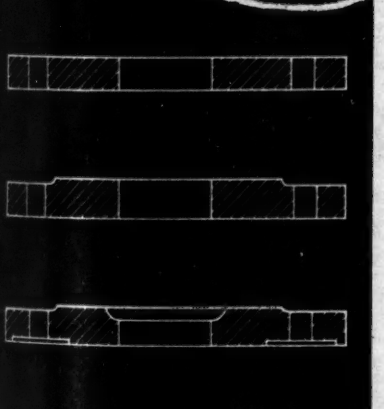

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NOTICE TO READERS
All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

UNIVERSITY OF WESTERN AUSTRALIA

SENIOR LECTURER IN CIVIL ENGINEERING

Applications are invited for the position of SENIOR LECTURER in CIVIL ENGINEERING. Applicants should hold a Degree in Engineering and have had practical experience in civil engineering. Research experience would be an advantage.

The salary range, which is under review at present, is £A1259 by £A50 to £A1509 per annum, which includes a present cost-of-living allowance of £A259. According to qualifications and experience, an appointment may be made within the range.

An allowance is made towards travelling expenses.

The successful applicant will be expected to commence duties as early as possible in 1955.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 5, Gordon Square, London, W.C.1.

The closing date for the receipt of applications, in Australia and London, is 30th October, 1954.

E5437

MANCHESTER MUNICIPAL COLLEGE OF TECHNOLOGY

(FACULTY OF TECHNOLOGY IN THE UNIVERSITY OF MANCHESTER)

APPOINTMENT OF LECTURER OR ASSISTANT LECTURER IN MECHANICAL ENGINEERING

The Governing Body invites applicatiotts for a LECTURESHIP or an ASSISTANT LECTURESHIP IN MECHANICAL ENGINEERING in the College of Technology, with the title and status of Lecturer or Assistant Lecturer in the University of Manchester.

The Department covers a very wide range of aspects of mechanical and production engineering, and all members of staff are expected to undertake, assist in or supervise research.

Salary: Lecturer, £650 per annum, rising by annual increments of £50 to £1200 per annum. Assistant Lecturer, £500 per annum, rising by annual increments of £25 to £600 per annum. Commencing salary according to qualifications.

Conditions of appointment and form of application may be obtained from the Registrar, College of Technology, Manchester, 1. The last day for the receipt of applications is 21st September, 1954.

Canvassing, either directly or indirectly, will disqualify a candidate for appointment.

B. V. BOWDEN,
E5417 Principal of the College.

LOUGHBOROUGH COLLEGE OF TECHNOLOGY

Principal: H. L. HASLEGRAVE, Wh.Sc., M.A. (Cantab), Ph.D. (Lond.), M.Sc. (Eng.), M.I.Mech.E. M.I.E.E., M.I.Prod.E.

LECTURER IN PRODUCTION ENGINEERING SUBJECTS

Applications are invited for the appointment of a LECTURER IN PRODUCTION ENGINEERING SUBJECTS. Candidates should be fully qualified engineers through apprenticeship, subsequent industrial training and experience, and technical education. Should be Corporate Members of at least one of the Institutions of Mechanical and Production Engineers, and should have had experience in engineering industry of production processes and planning.

Teaching duties will be concerned with the subjects of machine tools, metrology, production processes for full-time students in Diploma Courses and Specialist Courses.

Salary will be paid according to the scale £965 by £25 to £1065. Application forms and further particulars may be obtained from the Registrar, to whom completed applications should be sent as soon as possible, E5419

CITY OF BIRMINGHAM EDUCATION COMMITTEE

BROOKLYN FARM TECHNICAL COLLEGE

ALDRIDGE ROAD, GREAT BARR, BIRMINGHAM, 22A.

Principal: G. H. PALMER, M.Sc., A.Inst.P.

ASSISTANT (GRADE A)

Required, ASSISTANT (Grade A), to teach engineering science, engineering drawing and mathematics to pre-senior and S1 students. Duties to commence as soon as possible, and not later than 1st January, 1955. Candidates should hold appropriate academic qualifications and have had industrial experience. Forms of application, and further particulars of the post, may be obtained from the Principal of the College. Forms should be returned to him as soon as possible.

E. L. RUSSELL,
E5393 Chief Education Officer.

LONDON COUNTY COUNCIL

WANDSWORTH TECHNICAL COLLEGE

ASSISTANT, GRADE B

ASSISTANT, GRADE B, for electrical engineering subjects up to Higher National Certificate standard. Graduate qualifications, teaching and industrial experience desirable. Salary, Burnham (London) scale, varies between £561 and £982. Individual minimum and maximum according to age, qualifications and experience.—Application forms from Secretary at College, Wandsworth High Street, S.W.18, returnable by 25th September. (1085)

E5362

AIR MINISTRY

WORKS DEPARTMENT

MECHANICAL AND ELECTRICAL ENGINEERS

Air Ministry require MECHANICAL and ELECTRICAL ENGINEERS in Works Department for design, operation and maintenance of mechanical and electrical services on R.A.F. stations at home and overseas and civil aviation stations. Appointments in two grades: (a) Main Grade, salary scale £1000 to £1320; (b) Assistant Grade, £650 to £1000. Starting pay according to qualifications and experience. Salaries somewhat lower in provinces. Candidates should be age 25 or over. Appointments temporary and non-pensionable, but with long-term possibilities. Special allowance up to £1500 a year, according to location, payable in addition to salary during overseas service. Candidates must be natural-born British subjects of natural-born British parents.

Minimum qualifications and experience for both grades of posts: (i) (a) University Degree or equivalent Diploma in Electrical and/or Mechanical Engineering and at least a two-year apprenticeship; or (b) Graduate or Corporate Membership of the Institutions of Mechanical or Electrical Engineers, with appreciable electrical engineering experience and at least three years' apprenticeship; and (ii) employment in responsible position for minimum of three years with well-established engineering concern providing wide experience in electrical and mechanical engineering practice.

Application forms, quoting reference D1/54A, from M.L. and N.S., Technical and Scientific Register (K), Almack House, King Street, London, S.W.1.

E5386

WEST MIDLANDS GAS BOARD

WARWICKSHIRE DIVISION

MECHANICAL AND ELECTRICAL ENGINEER—FOLESHILL GAS WORKS, COVENTRY

Applications are invited from suitably qualified persons for the above post.

Candidates should have had extensive practical experience of the installation and maintenance of mechanical and electrical plant and equipment. Experience of gasworks practice would be an advantage.

Accommodation wil lbe available at a reasonable rental.

The commencing salary will not be less than £1000 per annum.

The post is pensionable and the successful candidate may be required to pass a medical examination.

Applications, stating age, qualifications and experience, together with the names of two referees, should be addressed to the Industrial Relations Officer, West Midlands Gas Board, 6, Augustus Road, Edgbaston, Birmingham, 15, to reach him within fifteen days of the appearance of this advertisement.

F. H. CURETON,
E5375 Secretary to the Board.

WESTERN REGIONAL PRODUCTION DEVELOPMENT BOARD

VACANCY FOR MECHANICAL ENGINEER

The Western Regional Production Development Board of Nigeria invites applications for the post of MECHANICAL ENGINEER. The duties of the post will include supervision and maintenance of the Board's Road Transport Fleet, including organisation and management of a maintenance workshop with attendant stores; acquisition, installation and maintenance of plant, machinery and agricultural equipment; providing information about and, where required, trying out new and experimental machinery and equipment.

The salary will be in the range of £1290–£1520, including expatriation allowance. The terms of service include free partly furnished accommodation; free medical service; outfit and children allowances; facilities for purchase of motor-car; liberal leave on full salary with first-class sea and air passages for officer and wife; contributed provident fund.

Applications, stating age, qualifications and experience, with the names of three referees, should be forwarded to reach the Administrative Manager, Western Regional Production Development Board, Secretariat, Ibadan, Nigeria, not later than 30th September, 1954. E5344

BRITISH ELECTRICITY AUTHORITY

HEADQUARTERS

THIRD ASSISTANT ENGINEER

British Electricity Authority require a THIRD ASSISTANT ENGINEER in the Research Sub-Department at Headquarters in London. Candidates should have at least three years' industrial experience and should preferably be Graduate Members of the I.E.E. or the I.Mech.E. The post demands a sound knowledge of the general principles underlying electricity supply techniques, rather than any specialised skill. Candidates should be interested in engineering development and have some mathematical ability and be mentally adaptable. There is unlikely to be much scope for experimental work, but familiarity with the aims and methods of research is desirable.

Salary: N.J.B. Grade 4, £753–£981 inclusive.

Applications, stating age, qualifications, experience, present position and salary, should be forwarded to D. Moffat, Director of Establishments, Winsley Street, London, W.1, by 4th October, 1954. Quote Ref. ENR./517. E5447

HER MAJESTY'S COLONIAL SERVICE

PUBLIC WORKS DEPARTMENT, KENYA

MECHANICAL ENGINEER (DEVELOPMENT)

Duties are the repair and maintenance of vehicles, earth-moving and static plant; the supervision of mechanical staff and the control of the expenditure of funds and workshop costing. Extensive travelling will be required.

Appointment will be on contract for four years in the scale £1135–£1782 gross, including cost-of-living allowance, entry point depending on qualifications and approved experience. Gratuity at 13½ per cent. of total salary drawn payable on termination of contract.

Free passages on appointment and on leave for officer, his wife and children up to a maximum cost of three adult passages. Leave at rate of 4½ days for each month of resident service.

Candidates up to 40 years of age should have passed, or be exempt from, Sections A and B of the examination for Associate Membership of the Institution of Mechanical Engineers.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number BCD.112/7/019/D4.

E5390

BRITISH ELECTRICITY AUTHORITY

SOUTH-EAST SCOTLAND DIVISION

SENIOR ASSISTANT ENGINEER GENERATION (OPERATION) DEPARTMENT

SENIOR ASSISTANT ENGINEER required in Generation (Operation) Department at Divisional Headquarters, Portobello.

Candidates must have highest technical qualifications in electrical and/or mechanical engineering, and should preferably have a First-Class Degree or equivalent in Electrical or Mechanical Engineering, together with Corporate Membership of the Institution of Electrical and/or Mechanical Engineers, and some experience in the design, operation and maintenance of steam electric power stations.

Salary £970–£1134 (N.J.B., Class AX/BX, Grade 1). Appointment superannuable.

Applications, on form AE.6/ACT, obtainable from Divisional Controller, British Electricity House, Portobello, Midlothian, should be completed and returned by 25th September, 1954. E5405

COUNTY BOROUGH OF EAST HAM

APPOINTMENTS

TEMPORARY ESTIMATOR, Grade V, £620–£670.

SENIOR QUANTITY SURVEYOR, Grade VI, £695–£760.

SENIOR ENGINEERING ASSISTANT, Grade VI, £695–£760.

London weighting is paid in addition. Salary in excess of the minima may be paid according to qualifications and experience.

Subsistence allowances may be granted over a reasonable period to persons appointed if unable to obtain suitable housing accommodation, necessitating the maintenance of two homes.

Further details and application forms returnable by 27th September, 1954, from the Town Clerk, Town Hall, East Ham, E.6. E5389

TRENT RIVER BOARD

SOUTHERN DIVISION

APPOINTMENT OF ASSISTANT ENGINEER

Applications are invited for the appointment of ASSISTANT ENGINEER at the Board's Divisional Office at Tamworth, Staffs. Salary within A.P.T. Grades V–VII (£620–£810) of the National Scheme of Conditions of Service, according to qualifications and experience. The appointment will be subject to the Local Government Superannuation Acts. The successful candidate will be concerned with the design and execution of land drainage works within the southern part of the Board's area.

Applications, with full particulars, including copies of testimonials or names of at least two referees, must reach the Engineer to the Board, P.O. Box No. 74, 206, Derby Road, Nottingham, not later than Monday, 27th September, 1954.

JOHN HIRST,
E5372 Clerk of the Board.

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION

PHYSICS DEPARTMENT

GRADUATE

GRADUATE required by the Fuel Technology Section of the Physics Department to investigate problems associated with the heating of steel in industrial furnaces. Applicants should be Graduates in Science, Technology or Engineering, with preferably strong mathematical background to use statistical methods, and undertake problems of steady heat flow. Starting salary up to £700 p.a., according to age, qualifications and experience. Age 23–27. Post is superannuated under the F.S.S.U. Location of work London.—Written applications only quoting "Fuel," to Personnel Officer, B.I.S.R.A. 11, Park Lane, London, W.1. E5409

GOLD COAST

PUBLIC WORKS DEPARTMENT

VACANCY FOR SENIOR MATERIALS ENGINEER

Applications are invited for a vacancy in the of SENIOR MATERIALS ENGINEER in Public Works Department of the Gold Government.

Duties: The officer appointed will be respo for the Materials Section of the Gold Coast P Works Department Roads and Bridges Br including all its field and laboratory activities deal mainly with the scientific investigation analysis of road construction materials. He wil advice as to the best use of local materials ava for road and other constructions and will advi all methods of stabilisation of local soils.

He will undertake research into the fundam properties of the main soils of the country in re to their suitability for road construction purp

The officer will also be responsible for the tra of subordinate laboratory and field staff.

Qualifications: Candidates should have a versity Degree in Science and should be qualifie Membership of the Institution of Civil Engi Candidates should possess good organising and be capable of handling staff. They should a minimum of ten years' post-graduate exper preferably on road or airport construction, inclu theoretical and practical experience of applie mechanics and analysis, with particular refere road construction materials of all types.

Terms of service: This post is a "develop post" for the implementation of specific pro under the Gold Coast Development Plan. appointment will be on contract/gratuity term one tour of 18 to 24 months, with a possible exte to two tours. Salary will be in the range of £2 £2500 per annum (consolidated), according to qualifications and experience. A gratuity at the of £37 10s. for each completed three months of factory service will be payable on final terminati the contract.

Free passages on first appointment and on will be provided for the officer and his wife once during each tour of service. Officers normally be required to travel by air. Fre passages will also be provided for a maximu three children under thirteen years of age.

Vacation leave with pay; seven days for month of service. Free medical and dental att provided for officer and family. Reasonable but standard partly furnished quarters are availab low rental on sites.

Intending candidates should apply in writing Adviser on Recruitment, Gold Coast Office, bourne House, Aldwych, London, W.C.2, for a of application. E5

WARWICKSHIRE COUNTY COUNCIL

ARCHITECT'S DEPARTMENT

APPOINTMENTS

Applications are invited for the following app ments:—

(1) ASSISTANT HEATING ENGINEER, extensive experience in the design of heating, ho cold water supplies and allied services, the pre tion of specifications, bills of quantities and est and the running of contracts. Membership Institution of Heating and Ventilating Engi required. Salary, £695, rising to a maximum of per annum.

(2) HEATING ENGINEERING ASSIST experienced in the preparation of schemes for he and hot water and specifications for such work limited supervision. Preference given to a Gra or Associate of the Institution of Heating Ventilating Engineers. Salary, £620, rising maximum of £760 per annum.

The appointments are on the established staff will be subject to the provisions of the Local Go ment Superannuation Acts, 1937-53. The succ applicants will be required to pass a medical exa tion.

Applications are to be made on a form whic be obtained from G. R. Barnsley, F.R.I County Architect, Shire Hall, Warwick.

L. EDGAR STEPHEN
Shire Hall, Clerk of the Coun
Warwick.
August, 1954. E5

PRODUCTION ENGINEERING RESEARCH ASSOCIATION

RESEARCH AND DEVELOPMENT W

MECHANICAL ENGINEER

MECHANICAL ENGINEER with good D is required for research and development wo metal machining and forming processes. For with initiative there are good opportuni advancement. Superannuation under F.S Full details, including age, experience, qualifica and salary required, to Secretary, Production neering Research Association, Melton Mowbra E5

THE BRITISH COAL UTILISAT RESEARCH ASSOCIATION

GRADUATE IN ENGINEERING, PHY OR CHEMISTRY

GRADUATE in ENGINEERING, PHYSI CHEMISTRY required for research and de ment work on industrial gas producers. P projects carried out in collaboration with ind furnace users, the work involves the operation semi-technical scale plant. Age 23–30 and sal accordance with age and qualifications. P scheme.—Apply in writing to Assistant Sec Ref. A.22, B.C.U.R.A., Randalls Road, Leath Surrey. E5

THE ENGINEER

SEPTEMBER 10, 1954

Opening of the Loch Luichart and Loch Dubh Hydro-Electric Stations

LAST week, the North of Scotland Hydro-Electric Board held opening ceremonies at two new power stations in Ross-shire. The Loch Luichart power station was opened on Friday, September 3rd, by Mrs. Ian Campbell, and on the following day Sir John Cameron opened the Loch Dubh (Ullapool) station at Strathkanaird. The Loch Dubh station has an installed capacity of 0·9MW and will generate about 5,600,000 kWh annually for local supply. The Loch Luichart power station has an installed capacity of 24MW, in two similar vertical Francis turbo-alternator sets operating under a gross head of 185ft, and will yield about 124 million kWh annually. This station and the dam associated with it, form the first stage of the Glascarnoch-Luichart-Torr-Achilty scheme, which was described in outline in our article on the Fannich scheme published in THE ENGINEER of June 8 and 15, 1951. The dam across Loch Luichart is a gravity structure, 45ft high and 680ft long, which has raised the level of the loch by about 40ft and provided 2400 million cubic feet of "live" storage. It incorporates a "Borland" hydraulic-elevator fish pass, which leads into the reservoir at the face of the tunnel intake; thus kelts and smolts going downstream will be induced into the pass by the main tunnel flow. Compensation water at the dam passes through an 85kW turbo-alternator set. The diversion tunnel and pipeline to the power station are very roughly a mile in length, the power station being built on the left bank of River Conon. The crane rails and roof of the power station are carried on steel stanchions between which are masonry walls of Tarradale stone, about 2ft thick. The consulting engineers are Sir Alexander Gibb and Partners (civil works) and Messrs. Merz and McLellan (electrical and mechanical). The contractor for the main plant was the English Electric Company, Ltd.; Glenfield and Kennedy, Ltd., supplied the water control gear, and the civil engineering contractors were respectively Reed and Mallik, Ltd., for the dam; George Wimpey and Co., Ltd., for the tunnel; and Duncan Logan (Contractors), Ltd., for the power station. The other works of the Glascarnoch-Luichart-Torr-Achilty scheme are making good progress and the Torr-Achilty and Achanalt works are well advanced. The entire group of schemes in the Conon Valley—including the earlier Fannich scheme and the Orrin scheme, work upon which has not yet started, will yield about 440 million kWh annually from six power stations totalling 107MW in capacity. The Loch Luichart station supersedes an earlier hydro-electric development. The old station, which was built in the nineteen-twenties, had three 500kW and one 1250kW sets, and generated nearly 14,000,000kWh in 1950 before it was closed down.

Productivity Report on Industrial Engineering

THE last of the sixty-seven reports of the British productivity teams that have visited the United States has just been published. This report on "industrial engineering" deals with the American approach to improvements in manufacture and to continuous reduction of operating costs. The team was led by Mr. W. F. Garnham, and the five main divisions of its investigations were as follows: effect of planning, control, budgeting and costing on improvement of manufacturing methods; relationship between design and methods of manufacture; means used on the factory floor to improve methods; effect of administrative arrangements on methods; and education. The report is presented in some twenty-two sections, at the end of each of which a number of recommendations are made. These recommendations are summarised in a chapter, in which under appropriate headings there are given the main matters to which it is considered attention could be directed with advantage by the average firm. It is suggested, amongst other things, that more small firms should be encouraged to specialise in certain types of products or components, and more shift working should be introduced to make economical use of expensive machinery. Other recommendations include the introduction of more detailed preparatory planning before operational decisions are made; a greater use of cost and performance figures; a more extensive use of specialised tools and fixtures; consideration of handling materials in relation to plant layout; preventive maintenance; greater use of motion and time study; the use of incentives; employee participation and suggestion schemes; the maintenance of close contact between industry and the technical press; and the introduction of independent advisory services by research and trade associations.

"Comet" Investigations

FOLLOWING much misleading comment on the possible causes of the "Comet" accidents, the Minister of Supply, Mr. Duncan Sandys, issued last Saturday a statement concerning the progress of the technical investigations at Farnborough and elsewhere. He said that "clear and positive results" had been forthcoming, which "indicate that some strengthening of certain parts of the structure of the 'Comet' is necessary." He had been advised, the statement continued, that these changes were entirely practical and should not involve any fundamental redesign of the aircraft. A modified "Comet" would then be tested at Farnborough. The Minister referred to the nature and scope of the investigation. Part of it, he said, had been concentrated on an examination of "Comet" wreckage which had been salvaged and pieced together. There had also been a test flying programme using "Comets" heavily instrumented to record temperatures, vibrations and other conditions in their vital parts. And, finally, there had been a series of exhaustive structural tests. A detailed and comprehensive report of this work, he said, would be laid before the Court of Inquiry.

Ffestiniog and Rheidol Hydro-Electric Schemes

WE learn that the British Electricity Authority is seeking the consent of the Minister of Fuel and Power to promote a bill in the forthcoming Parliamentary Session for the development of the Ffestiniog pumped storage scheme and the Rheidol hydro-electric scheme in North Wales. These schemes are designed to provide about 349MW of generating capacity. It will be recalled that the proposals made in 1952 for hydro-electric development in these areas were deferred because of restrictions in capital expenditure. In its original form the Rheidol scheme provoked some opposition because of the proposals to divert the head waters of the Rivers Severn and Wye into the Rheidol catchment, and those of the Rheidol into the Dovey estuary; these proposals have been discarded and the Authority considers that the revised schemes now proposed are a marked improvement on the earlier ones in regard to their effects on local amenities. Due regard would be paid to riparian interests by providing for the discharge of reasonable quantities of water below each of the points of extraction in both schemes. The proposed works for the Ffestiniog scheme would be near the village of Blaenau Ffestiniog and close to the mining district. The scheme would use the existing Llyn Stwlan as an upper reservoir, and its storage capacity would be increased by a concrete dam 90ft high and about 900ft long. The lower reservoir would be formed by another concrete dam 35ft high and about 1800ft long immediately upstream of the village of Tan-y-Grisiau in the valley of the Afon Ystradau. Between the two reservoirs, which would probably be connected partly by a tunnel and partly by surface pipelines, there would be a head of approximately 1000ft. The power station on the edge of the lower reservoir, would contain six combined generating and pumping sets, each consisting of a water turbine, centrifugal pump and generator/motor, and ancillary plant. It is envisaged that the annual output of about 300 million units from the Ffestiniog scheme would be fed into a section of the 275kV supergrid through a new switching station adjacent to the pump storage station. The Rheidol scheme is situated about 10 miles due east of Aberystwyth. The available head would be used in two main stages, providing a total generating capacity of 49MW. In the upper stage a reservoir would be formed by a dam across the Afon Rheidol near Nant-y-Moch. It would be connected by a tunnel and a short surface pipeline to a power station some 2 miles downstream of the dam and discharging into the same river. The lower stage would comprise a small balancing reservoir formed by a dam across the Rheidol just below the upper power station and connected by a 3-mile long tunnel to a second power station discharging into the Rheidol, a short distance below the Rheidol falls. The water would be returned into the lower reaches of the river and, to avoid disturbance of the river regime by the intermittent discharges, a regulating pond would be formed by a small dam, creating a head of which advantage would be taken to generate an additional 1000kW. Part of the 83,000,000 units per annum output from the Rheidol scheme would be fed into the national grid by means of a new 132kV transmission line between Rheidol and Oswestry. The remainder would be used to supply the local demand.

Applied Research in Technical Colleges

THE Regional Advisory Council for Higher Technological Education in London and the Home Counties has published a report dealing with the development of applied research in technical colleges. The report, which has been compiled by a special committee of the Council, explains that about four years ago local education authorities in the region were urged to appoint a limited number of research assistants or demonstrators. Since then, it is stated, about two dozen posts of this kind have been approved in London and the Home Counties, and most of them have been filled, with the result that opportunities for research in colleges maintained or aided by the local authorities have been correspondingly increased. The report gives some particulars of the researches completed or in progress in several of the senior technical colleges in the region. It says that an analysis of the research published and higher degrees obtained shows a distinct bias towards chemistry and biology in general and organic chemistry in particular. The report goes on to comment that "although all such research may at some time have a bearing on industrial problems, the Regional Council thinks it not unfair to say that relatively few of the published researches listed in organic chemistry appear to have been undertaken in direct co-operation with industry." About engineering research, the report says that, from the evidence collected, it would appear that chemistry departments in colleges have usually found it easier to provide facilities than have the engineering departments; the expansion of engineering research in technical colleges would be helped by some increase in the workshop staff available to help research workers in the construction and maintenance of the necessary equipment. In general, the report adds, it is abundantly clear that the principal obstacle to the further development of industrial research in many technical colleges is lack of laboratory space.

Machine Design for Cyclic Stress

By J. S. CASWELL *

No. II—(*Continued from page 321, Sept. 3rd*)

The customary methods of machine design for static stress are unsatisfactory for the purposes of cyclic stress design. The characteristics and the effects of cyclic stressing are discussed and reference is made to the use of base diagrams for design purposes. The serious effects of stress concentration are considered and new formulæ are presented for use in cyclic stress design. These formulæ make provision for counteracting the effects of stress concentration and also for taking some account of the effect of a quality change between the fatigue test specimen and the service part. The value of the correction factor used may be altered to take account of the useful effects of special surface treatments of machine parts. The applications of the proposed methods of design are considered in relation to cyclic stresses which arise in direct loading, eccentric loading, bending, torsion, and combined bending and torsion. A few examples with detailed solutions are included to illustrate design procedure.

Safe Stresses with Stress Concentration

THE safe stress boundary line in Fig. 5 (*b*) *ante* is assumed to be at *DE*, parallel to the failure-boundary line. For a mean stress σ_m', the permissible stress increment produced by the applied loading and stress concentration is $k'\sigma_v'$ represented by the ordinate $F'G'$. Comparison of the triangles $EF'G'$ and BOA would be similar to that applied earlier, on page 320, to Fig. 5 (*b*), except that $k'\sigma_v'$ is used instead of σ_v. Consequently, the required safe value of the mean stress may be expressed as :—

$$\sigma_m=\frac{\phi}{k\alpha\beta\gamma+1} \quad . \quad . \quad . \quad . \quad (6)$$

and the average value of the variable stress component is

$$\sigma_v=\alpha\sigma_m$$

where α is the loading or stressing ratio.

The Factors k, K_f, K_σ and K_ϕ.—It is important to observe that k is a coefficient applied only to the variable stress component and therefore it is not a stress concentration factor in the true meaning of this term, e.g. as implied in the definitions of K_σ and K_f already given. Soderberg,[1] who proposed the triangular base diagram for cyclic stress design, was careful to point out that k is the "appropriate stress concentration factor —for the conditions of the problem in question" and that it operates to produce a "weighting factor" which can be added to the steady mean stress. In discussions of this matter in several books on machine design and strength of materials and in some published papers, the coefficient k is given the meaning normally attached to K_σ or K_f and it is also implied that stress concentration does not affect the steady stress or mean stress, and some experimental results on combined stresses by Gough, Pollard and Clenshaw[14, 20] seem to give some support to these ideas. Both of these views appear to be incorrect for the reasons given below :—

(1) Photo-elastic examination of the stress conditions over a cyclic stress range of ordinary frequency shows that stress concentration is a consequence of the effect of external surface form on the total or absolute stress in a part. In order to demonstrate this point, the writer made photographs of the photo-elastic fringe patterns which were produced when a Bakelite model of a machine part was subjected to pure bending moments $+M_1$ (max.) and $+M_2$ (min.) and also to the mean, and supposed steady bending moment $+M_m$. Reproductions of these photographs appear in Fig. 8 in the order corresponding to M_2, M_m and M_1, and it will be observed that the stress concentration factor K_t for the larger notch has a value of approximately 1·20, while the value of k, applying to $k\sigma_v$ is 1·50, which is only 5 per cent below

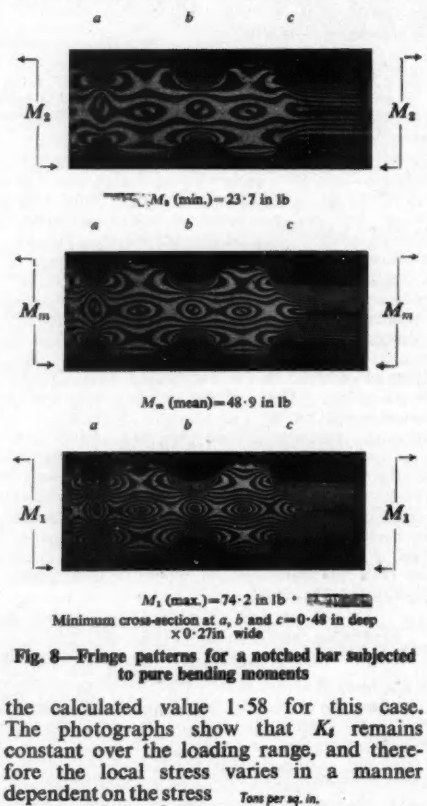

Fig. 8—Fringe patterns for a notched bar subjected to pure bending moments

the calculated value 1·58 for this case. The photographs show that K_t remains constant over the loading range, and therefore the local stress varies in a manner dependent on the stress concentration factor K_t for the notch and the magnitude of the absolute average stress over the cross section at the notch. If k is given the value 1·20, $k\sigma_v$ makes the peak stress too low. In the real materials of machine construction the relevant stress concentration factor would be the actual operative stress concentration factor K_ϕ within safe ranges of stress or the failure limit concentration factor K_σ. These photographs do not support the view that the stress concentration factor should be applied only to the variable stress component.

(2) The stressing ratio for plain or notched parts under cyclic loading is $\alpha=\sigma_v/\sigma_m$ and this ratio is determined by the applied loading limits as explained earlier on page 319. For a given cross-sectional area, the values of the uniform or average stresses, $\sigma_m-\sigma_v$ and $\sigma_m+\sigma_v$ for assigned load limits, remain constant, and, therefore, the stressing ratio $\alpha=\sigma_v/\sigma_m$ is independent of the external form, but the permissible values of σ_m and σ_v depend on the external form and therefore on the stress concentration factor K_σ. If this factor is applied only to the variable stress component, the following anomaly arises.

If *ODE* (Fig. 9) is the safe limit base diagram and the value of the factor k for a given notch is 1·2, then for a mean stress $\sigma_m=2\cdot0$ (*OF*) and a stressing ratio $\alpha=3$, the permissible value of $\sigma_v=5\cdot57$ (*FH*) and $k\sigma_v=1\cdot2\times5\cdot57$ (*FG*)=6·67, therefore $\sigma_m+\sigma_v=7\cdot57$ and $\sigma_m+k\sigma_v=8\cdot67$, giving an excess of 1·10 due to stress concentration.

If for the same bar the stressing ratio is altered to 1/10, then for a mean stress $\sigma_m=8\cdot0$ (*OF'*), the permissible value of $\sigma_v=2\cdot22$ (*F'H'*) and $k\sigma_v=1\cdot2\times2\cdot22=2\cdot66$ (*F'G'*). Therefore, $\sigma_m+\sigma_v=10\cdot22$ and $\sigma_m+k\sigma_v=10\cdot66$, which is an excess of only 0·44, i.e. a lower excess, although the maximum average stress (10·66) is higher. Such a result is contrary to what would be expected in a notched bar under increasing load, i.e. increasing excess of stress. Moreover, when the value of $k\sigma_v=0$, the mean stress $\sigma_m=\sigma_y/n=\phi$, implying that stress concentration has disappeared and that the stress over the cross section is then uniform and independent of the form of the surface. The photographs reproduced in Fig. 8 show that this would not be so. Consequently, the value k should not be regarded as a stress concentration factor in the true sense because its value referred to total stress is changing in a manner dependent on the stressing ratio α and the stress concentration factor K_σ or K_ϕ for the notch. It seems that the anomaly arises because the notch effect on the mean stress is neglected. The limit boundary for σ_v due to the factor k is *S.E.* A proposed limit boundary *ST* (Fig. 9) is based on the new approach discussed below.

Proposed New Formulæ for Cyclic Stress Design with Stress Concentration

Referring to Figs. 7 (*b*) and 7 (*c*) *ante* the peak stress may be represented by either of the expressions $\sigma_m+k\sigma_v$ or $K_\sigma(\sigma_m+\sigma_v)$ where k and K_σ have the meanings already explained. Then:—

$$\sigma_m+k\sigma_v=K_\sigma(\sigma_m+\sigma_v) \quad . \quad . \quad . \quad (7)$$

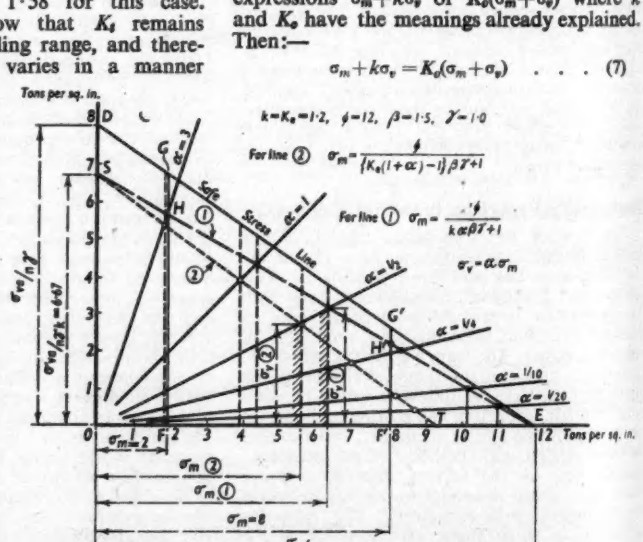

Fig. 9—Comparison of values of σ_m and σ_v calculated from the modified formula 1 and the proposed new formula 2 for the conditions defined

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or

$$1+k\frac{\sigma_v}{\sigma_m}=K_o\left(1+\frac{\sigma_v}{\sigma_m}\right)$$

and

$$\sigma_v/\sigma_m=\alpha$$

then

$$1+k\alpha=K_o(1+\alpha)$$
$$k\alpha=K_o(1+\alpha)-1$$

and

$$k=\frac{1}{\alpha}\{K_o(1+\alpha)-1\} \quad . \quad . \quad (8)$$

where

k=the coefficient affecting the variable stress component σ_v.

K_o=the operative stress concentration factor for the notch. (The precise way in which K_o varies between K_f and K_t is not known and therefore the known values of K_t should be used. In general perhaps $K_f>K_o>K_t$.)

α=the stressing ratio σ_v/σ_m, found as explained earlier.

Consequently, the substitution for k as shown gives rise to important formulæ which are, as far as the author is aware, quite new in machine design method for cyclic stress with stress concentration for direct loading and bending. For the simple form of straight-line diagram, Fig. 5 (*b*) *ante*, the average value of the safe mean stresses is

$$\sigma_m=\frac{\phi}{\{K_e(1+\alpha)-1\}\beta\gamma+1} \quad . \quad . \quad (9)$$

and for the modified knee type diagram, to be reproduced (Fig. 19), and discussed later

$$\sigma_m=\frac{\rho\phi}{\{K_e(1+\alpha)-1\}\rho\beta\gamma+1} \quad . \quad . \quad (10)$$

or

$$\sigma_m=\frac{\phi}{K_e(1+\alpha)} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

depending on the values of the factor K_e and the ratio α, and the permissible average value of the variable component is $\sigma_v=\alpha\sigma_m$, where ρ is a modifying coefficient and the other values have the meanings already assigned to them. With other terms remaining equal, the formulæ give working stresses which are lower than those obtained by applying the stress concentration factor only to the variable component σ_v, thus keeping design on the safer side.

By the use of well-chosen values of the correction factors, the formulæ may be made to correspond more closely to the safety margins which are fixed in relation to the endurance tests results in any particular case. There is very urgent need for a generalised method of procedure accompanied by a range of operative stress concentration factors for standard forms of notches, perforations and fillets. Detailed consideration of the modified knee type diagram is given later. Two examples illustrating design procedure with stress concentration on the basis of the first equation (9) are given below, and a comparison of the values of σ_m and σ_v calculated by formula (6) and the new formula (9) are shown in Fig. 9.

Example 2.—A steel bar, reduced in diameter as shown in Fig. 10, is required to carry a fluctuating tensile load ranging from 16·8 tons to 6·4 tons. The fillet radius r is to be approximately one-fifth of the diameter d and the corresponding effective factor of stress concentration is assumed to be 1·38. The steel used has a yield strength of 23·7 tons per square inch and an endurance limit of 17·8 tons per square inch under alternating stress. The correction factor for fatigue is 1·15. Determine suitable dimensions, assuming a factor of safety of 2·5 on the base diagram.

Solution.—

$$P_1=+16\cdot8,\ P_2=+6\cdot4,$$
$$\sigma_y=23\cdot7,\quad \sigma_{vo}=17\cdot8,\ \gamma=1\cdot15,$$
$$K_e=1\cdot38,\quad n=2\cdot5.$$

The assigned maximum mean stress

$$\phi=\frac{23\cdot7}{2\cdot5}=9\cdot48 \text{ tons per square inch.}$$

The stressing ratio

$$\alpha=\frac{P_1-P_2}{P_1+P_2}=\frac{10\cdot4}{23\cdot2}=0\cdot45.$$

The base diagram ratio

$$\beta=\frac{\sigma_y}{\sigma_{vo}}=\frac{23\cdot7}{17\cdot8}=1\cdot33.$$

Permissible mean stress:—

$$\sigma_m=\frac{\phi}{\{K_e(\alpha+1)-1\}\beta\gamma+1}$$
$$=\frac{9\cdot48}{[\{1\cdot38(0\cdot45+1)-1\}1\cdot33\times1\cdot15]+1}$$
$$=3\cdot75 \text{ tons per square inch}$$

$$\sigma_v=\alpha\sigma_m=0\cdot45\times3\cdot75=1\cdot69 \text{ tons per square inch}$$

and

$$\sigma_m+\sigma_v=3\cdot75+1\cdot69=5\cdot44 \text{ tons per square inch.}$$

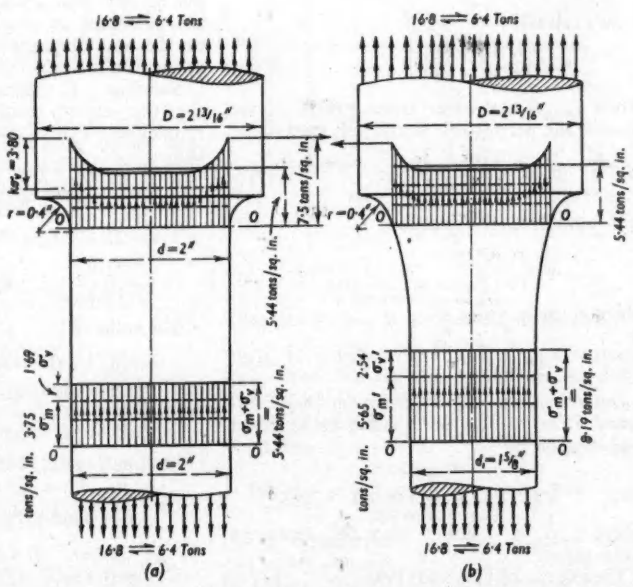


Fig. 10—Diagram to illustrate the design method described in Example 2

Maximum load

$$P_1=(\sigma_m+\sigma_v)\frac{\pi}{4}d^2$$

$$d=\left(\frac{4\times16\cdot8}{\pi\times5\cdot44}\right)^{\frac{1}{2}}=1\cdot99\text{in.}$$

The required dimensions are then :

The diameter d=1·99, say, 2·0in.

The fillet radius $r=d/5=0\cdot40$in.

If a 90 deg. fillet is to be maintained the diameter $D=d+2r$,

$$=2\cdot0+0\cdot8=2\cdot80\text{in,}$$
say, $2\frac{13}{16}$in.

The diameter d of the parallel part of the bar could be made slightly less than the calculated value 1·99 because the maximum stress intensity occurs on a line lying just behind the line of transition from the fillet to the parallel part of the shaft (see Fig. 10 (a)).

It is of interest to observe that at a short distance away from the fillet the stresses produced become uniform over the cross section, so that the mean stress could then have the value:—

$$\sigma_m{}^1=\frac{\phi}{\alpha\beta\gamma+1}$$
$$=\frac{9\cdot48}{(0\cdot45\times1\cdot33\times1\cdot15)+1}$$
$$=5\cdot65 \text{ tons per square inch}$$

$$\sigma_v{}^1=\alpha\sigma_m'=0\cdot45\times5\cdot65=2\cdot54$$

$$\sigma_m'+\sigma_v'=8\cdot19 \text{ tons per square inch}$$

and

$$P_1=(\sigma_m{}^1+\sigma_v{}^1)\frac{\pi}{4}d_1{}^2$$

$$d_1=\left(\frac{4\times16\cdot8}{\pi\times8\cdot19}\right)^{\frac{1}{2}}=1\cdot62\text{in (1}\tfrac{5}{8}\text{in).}$$

Consequently, the transition from the fillet to the parallel part could take the form shown in Fig. 10 (*b*) with the stresses at assigned safe limits at the fillet and in the parallel part of the bar. This indicates that the elliptical form of fillet offers a better line of transition from the enlarged part to the smaller parallel part. This form of fillet reduces the stress concentration factor compared with that for the constant radius fillet, and therefore the design could be a little lighter at the fillet. Investigations of stress concentration factors for elliptical fillets have been carried out by Grodzinski[8] and Berkey.[9]

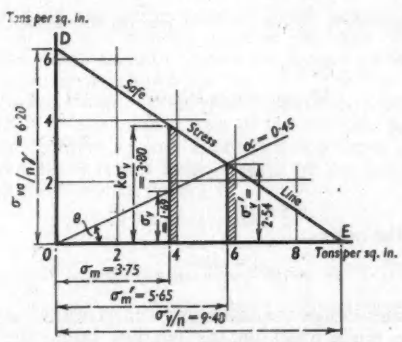


Fig. 11—Safe stress values for Example 2, corresponding to those shown in Fig. 10

The calculated stresses in the foregoing problem are shown on the base diagram, Fig. 11, and the stress variations are shown in Fig. 10.

Example 3.—A non-rotating journal, Fig. 12, forming a rigid part of a sliding head, is required for transmitting reversing loads ranging from 4·8 tons to 2·6 tons represented by point loads located as shown. The steel has a yield stress σ_y of 27·24 tons per square inch and an alternating stress endurance limit of 20·5 tons per square inch. The inner fillet has a radius equal to one-eighth of the journal diameter, and the corresponding stress concentration factor is 1·45. Determine the diameter of the journal assuming a factor of safety of 3 on

the base diagram and a fatigue correction factor=1·08.

Solution.—Maximum bending moment M_1 =4·8×7·5=+36in-tons. Reversed bending

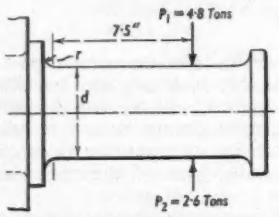


Fig. 12—Fixed journal pin subjected to reversing bending moments, (Example 3)

moment $M_2=-2\cdot6\times7\cdot5=-19\cdot5$in - tons

$\sigma_y=27\cdot24$, $\sigma_{vo}=20\cdot5$

$K_e=1\cdot45$, $n=3\cdot0$, $\gamma=1\cdot08$.

The assigned maximum mean stress

$\phi=\sigma_y/n=27\cdot24/3=9\cdot08$ tons per square inch.

The stressing ratio

$$\alpha=\frac{M_1-(-M_2)}{M_1+(-M_2)}=\frac{36+19\cdot5}{36-19\cdot5}$$
$$=3\cdot37.$$

The base diagram ratio

$$\beta=\frac{\sigma_y}{\sigma_{vo}}=\frac{27\cdot24}{20\cdot5}=1\cdot33.$$

Permissible mean stress,

$$\sigma_m=\frac{\phi}{\{K_e(\alpha+1)-1\}\beta\gamma+1}$$
$$=\frac{9\cdot08}{[\{1\cdot45(3\cdot37+1)-1\}1\cdot33\times1\cdot08]+1}$$
$$=1\cdot045(1\cdot05)\text{ tons per square inch.}$$

$\sigma_v=\alpha\sigma_m=3\cdot37\times1\cdot045=3\cdot52$,

$\sigma_m+\sigma_v=1\cdot05+3\cdot52=4\cdot57$ tons per square inch.

Then

$$M_1=(\sigma_m+\sigma_v)\frac{\pi}{32}d^3$$

and

$$d=\left(\frac{32\times36}{4\cdot57\times\pi}\right)^{\frac{1}{3}}=4\cdot31\text{in}$$
$$=4\tfrac{5}{16}\text{ in.}$$

Fillet radius,

$$r=d/8=\frac{4\cdot31}{8}=0\cdot54=\tfrac{9}{16}\text{ in.}$$

Fuller design would require consideration of the pinch effect on the pin just inside the boss.

Eccentric Loading

A more difficult problem arises when machine parts are eccentrically loaded. Such a problem arises in the design of the cranked suspension bar shown in Fig. 13.

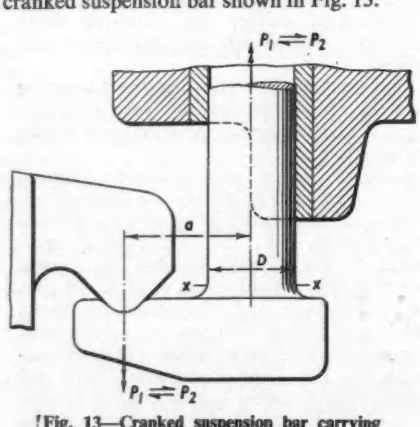


Fig. 13—Cranked suspension bar carrying fluctuating loads

For Direct Loading (*Suffix* "*d*")—In this case, referring to the cross section *xx* in Fig. 13, let

σ_{md}=the direct loading part of the mean stress,

σ_{vd}=the direct loading part of the semi-range of stress.

Then

$$(\sigma_{md}+\sigma_{vd})\frac{\pi}{4}D^2=P_1 \quad . \quad . \quad . \quad (12)$$

$\sigma_{vd}=\alpha\sigma_{md}$, where α is the stressing ratio, and on substituting in the equation the value of σ_{md} is given by

$$\sigma_{md}=\frac{4P_1}{\pi D^2(1+\alpha)} \quad . \quad . \quad . \quad . \quad (13)$$

For Bending (*Suffix* "*b*").—σ_{mb} and σ_{vb} are the superimposed stresses produced by bending, and

$$\sigma_{mb}+\sigma_{vb}=\frac{M_1}{Z}=\frac{P_1a}{Z}=\frac{32P_1a}{\pi D^3} \quad . \quad (14)$$

where

Z=modulus of the section=$\frac{\pi D^3}{32}$.

a=distance of P_1 from the centre-line of the bar.

The stressing ratio due to bending is the same as that for the direct loading, viz., α; therefore,

$$\sigma_{vb}=\alpha\sigma_{mb},$$

and on substitution, the value of σ_{mb} is given by

$$\sigma_{mb}=\frac{32P_1a}{\pi D^3(1+\alpha)} \quad . \quad . \quad . \quad (15)$$

Combined Loading (*Suffix* "*c*").—The combined mean stresses,

$$\sigma_{md}+\sigma_{mb}=\sigma_{mc}.$$

The combined semi-ranges,

$$\sigma_{vd}+\sigma_{vb}=\sigma_{vc}.$$

Therefore,

$$\sigma_{mc}=\frac{4P_1}{\pi D^2(1+\alpha)}+\frac{32P_1a}{\pi D^3(1+\alpha)},$$

or mean stress,

$$\sigma_{mc}=\frac{4P_1(D+8a)}{\pi D^3(1+\alpha)} \quad . \quad . \quad . \quad . \quad . \quad (16)$$

When σ_{mc}, D and other terms except P_1 are known, the permissible maximum load is :

$$P_1=\frac{\sigma_{mc}\pi D^3(1+\alpha)}{4(D+8a)} \quad . \quad . \quad . \quad . \quad . \quad (17)$$

P_2 is found from the relation

$$\alpha=\frac{P_1-P_2}{P_1+P_2}$$

which gives the value of

$$P_2=\left(\frac{1-\alpha}{1+\alpha}\right)P_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

Determination of the Diameter D (*Compound Stress.*)—The permissible mean stress is also given by

$$\sigma_{mc}=\frac{\phi}{\{K_e(\alpha+1)-1\}\beta\gamma+1} \quad . \quad . \quad (19)$$

where ϕ, K, α, β and γ have the meanings given earlier.

Then equating (16) and (19),

$$\frac{4P_1(D+8a)}{\pi D^3(1+\alpha)}=\frac{\phi}{\{K_e(\alpha+1)-1\}\beta\gamma+1}.$$

Let

$$\lambda=\{K_e(\alpha+1)-1\}\beta\gamma+1$$

Then

$$\phi\pi D^3(1+\alpha)=4P_1D\lambda+32P_1a\lambda$$

or

$$D^3-\left[\frac{4P_1\lambda}{\phi\pi(1+\alpha)}\right]D-\frac{32P_1a\lambda}{\phi\pi(1+\alpha)}=0 \quad . \quad (20)$$

Obtain values of the coefficient of D and the constant giving

$$\frac{4P_1\lambda}{\phi\pi(1+\alpha)}=B$$

and

$$\frac{32P_1a\lambda}{\phi\pi(1+\alpha)}=C.$$

Then

$$D^3-BD-C=0 \quad . \quad . \quad . \quad . \quad (21)$$

Draw the graphs of $y_1=D^3$ and $y_2=BD+C$ and the intersection of the graphs, giving $y_1-y_2=0$, locates the value of D which satisfies the equation (21).

The following example illustrates the application of the method.

Example 4.—A forged steel offset rod *AB* (Fig. 14 (*a*)) is used to give reciprocating motion to a second rod *CE*, offset 3in, and under operating conditions a reversing force must be applied to the rod *AB*, ranging from $P_1=+2\cdot4$ tons to $P_2=-0\cdot4$ ton, as shown in the figure. The offset arm is machined to the form shown in Fig. 14 (*b*). The factor of stress concentration for the clearance groove is 1·65 and the yield stress and the alternating stress endurance limit of the steel are respectively 22·8 and 17·5 tons

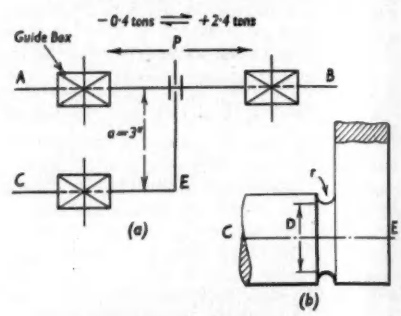


Fig. 14—Design of offset rod, discussed in Example 4

per square inch. Calculate the diameter of the clearance groove if the factor of safety on the base diagram is 1·80, and the fatigue correction factor is 1·13.

Solution.—The stressing ratio α is the same for the direct loading and the bending moments. $P_1=+2\cdot4$ tons and $P_2=-0\cdot4$ ton.

$$\alpha=\frac{P_1-P_2}{P_1+P_2}=\frac{2\cdot4-(-0\cdot4)}{2\cdot4+(-0\cdot4)}=1\cdot40,$$

$\sigma_y=22\cdot8$; $\sigma_{vo}=17\cdot5$; $n=1\cdot8$; $a=3$in,

$\beta=\frac{22\cdot8}{17\cdot5}=1\cdot3$; $K_e=1\cdot65$; $\gamma=1\cdot13$.

The value of

$\lambda=\{K_e(1+\alpha)-1\}\beta\gamma+1$

$=[\{1\cdot65(1+1\cdot4)-1\}1\cdot3\times1\cdot13]+1$

$=5\cdot35$.

In equation (21) the values of B and C are

$$B=\frac{4P_1\lambda}{\phi\pi(1+\alpha)}=\frac{4\times2\cdot4\times5\cdot35}{12\cdot7\times\pi(1+1\cdot4)}=0\cdot54$$

$$C=\frac{32P_1a\lambda}{\phi\pi(1+\alpha)}=\frac{32\times2\cdot4\times3\times5\cdot35}{12\cdot7\pi(1+1\cdot4)}=12\cdot90.$$

The equation for D is then

$$D^3-0\cdot54D-12\cdot90=0,$$

and this is satisfied by a value of $D=2\cdot42$in and therefore the groove should have a diameter of approximately $2\frac{3}{8}$in. The ratio of fillet radius to diameter, corresponding to the factor of stress concentration, is approximately 0·12. Therefore, the fillet

radius should be=0·29in—approximately $\frac{5}{16}$in.

Calculation of Loads for Existing Parts

It is sometimes necessary to calculate the safe loads that can be applied to a machine part already in existence. The following example illustrates the procedure.

Example 5.—A forked suspension bar has the form shown in Fig. 15 and the values of the yield stress and the alternating stress endurance limit are respectively 25·5 and 20·4 tons per square inch. The diameter of the bar at the section *xx* is 2in, the fillet has a stress concentration factor $K_e=1·4$, and the offset of the centre lines is $\frac{1}{2}$in. The bar is required to carry a fluctuating load, such that the maximum tensile load is twice

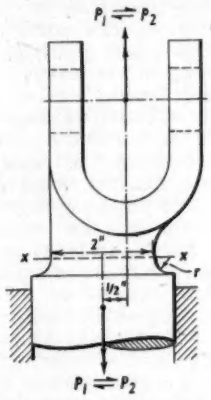


Fig. 15—Offset fork link analysed in Example 5

the minimum tensile load. Determine the magnitude of these loads if the factor of safety on the base diagram is 3, and the correction factor $\gamma=1·07$.

Solution.—The stressing ratio,

$$\alpha=\frac{P_1-P_2}{P_1+P_2} \text{ and } P_2=P_1/2,$$

therefore

$$\alpha=\frac{P_1-P_1/2}{P_1+P_2/2}=\frac{1}{3}\ ;\quad n=3\ ;$$

$$\phi=\frac{25·5}{3}=8·5\ ;\quad \beta=\frac{25·5}{20·4}=1·25$$

$$K_e=1·4\ ;\quad a=0·5\text{in}\ ;\quad \gamma=1·07.$$

The permissible mean stress is given by equation (19), when the above values are inserted. This gives $\sigma_{mc}=3·93$ tons per square inch. Then using equation (17) the maximum load P_1 may be found,

$$P_1=\frac{\sigma_{mc}\pi D^3(1+\alpha)}{4(D+8a)}$$

$$=\frac{3·93\pi 2^3(1+\frac{1}{3})}{4\{2+(8\times 0·5)\}}=5·50 \text{ tons}$$

and

$$P_2=P_1/2=2·75 \text{ tons.}$$

It will be of interest perhaps to calculate the stresses in stages and so verify that they comply with the requirements of the base diagram, Fig. 16 (*b*).

For the Direct Loads.—

$$P_1=(\sigma_{md}+\sigma_{vd})\frac{\pi}{4}D^2 \text{ where } D=2"$$

Therefore

$$\sigma_{md}+\sigma_{vd}=\frac{5·50}{3·14}=+1·75 \text{ tons per square inch}$$

and for

$$P_2=P_1/2,\ \sigma_{md}-\sigma_{vd}=1·75/2=0·875 \text{ tons per square inch,}$$

and therefore

$$\sigma_{md}=+1·312 \text{ tons per square inch,}$$

For the Bending Moments.—

$$P_1a=\frac{\pi}{32}D^3(\sigma_{mb}+\sigma_{vb}),$$

Therefore

$$\sigma_{mb}+\sigma_{vb}=\frac{32\times 5·50\times 0·5}{\pi 2^3}$$

$$=\pm 3·50 \text{ tons per square inch}$$

giving $+3·5$ for the right side, Fig. 15, and $-3·5$ for the left side, Fig. 15, and $P_2=P_1/2$.

Therefore

$$\sigma_{mb}-\sigma_{vb}=3·5/2=\pm 1·75 \text{ tons per square inch,}$$

giving $+1·75$ for the right side, Fig. 15, and $-1·75$ for the left side, Fig. 15, and $\sigma_{mb}=\pm 2·625$.

Therefore

$$\sigma_{mc}=\sigma_{md}+\sigma_{mb}=3·94=OF_1 \text{ and}$$

$$\sigma_{vc}=\sigma_{vd}+\sigma_{vb}=1·31=F_1H_1.$$

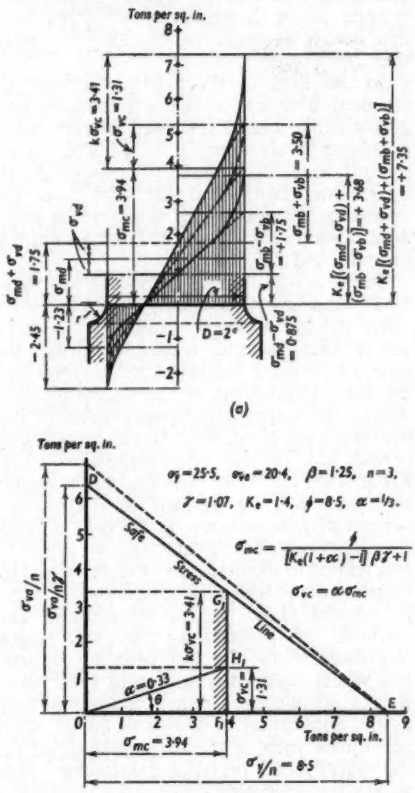
The collected stresses, unaffected by stress concentration, are then :

For the Right Side.—

Under $P_1=+1·75+3·5=+5·25$

Under $P_2=+0·875+1·75=+2·625$,

giving concentrated stresses ranging from $1·4\times 5·25=+7·35$ tons per square inch



(*a*) Distribution of stress.
(*b*) Safe stress base diagram.

Fig. 16—Stresses in the fork link of Example 5

to $1·4\times 2·625=+3·68$ tons per square inch, thus making $k\sigma_{vc}=7·35-3·94=3·41$ tons per square inch.

For the Left Side.—

Under $P_1=+1·75-3·5=-1·75$ tons per square inch.

Under $P_2=+0·875-1·75=-0·875$ tons per square inch,

giving concentrated stresses ranging from $1·4\times(-1·75)=-2·45$ tons per square inch to $1·4\times(-0·875)=-1·225$ tons per square inch.

These stresses and the concentrated stresses are shown to scale in Fig. 16 (*a*) and they agree with the safe stress requirements of the safe base diagram shown in Fig. 16 (*b*).

Unsymmetrical Bars in Bending

The symmetry of a machine part may be interrupted by a notch on one side of the part or by the presence of a hole drilled off centre. The problem in design is to make the dimensions of the part in the vicinity of the interruption large enough to ensure that the concentrated stress produced by the interruption, does not exceed a safe value. A notched rectangular bar is shown in Fig. 17 and it is subjected to bending moments varying continuously from M_1 to M_2. The permissible

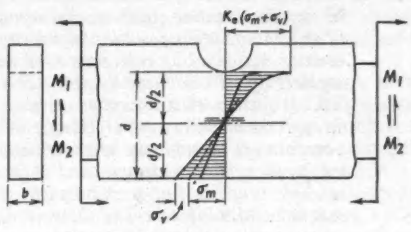


Fig. 17—Stresses in a notched beam

mean stress and semi-stress range at the base of the notch are respectively σ_m and σ_v. If M_1 is the maximum bending moment and b is the width of the bar,

$$(\sigma_m+\sigma_v)\frac{bd^2}{6}=M_1$$

or

$$\left(1+\frac{\sigma_v}{\sigma_m}\right)\frac{bd^2}{6}=\frac{M_1}{\sigma_m}$$

i.e.

$$(1+\alpha)\frac{bd^2}{6}=\frac{M_1[\{K_e(1+\alpha)-1\}\beta\gamma+1]}{\phi}$$

and the required depth of the bar at the notch is given by

$$d=\left[\frac{6M_1[\{K_e(1+\alpha)-1\}\beta\gamma+1]}{b\phi(1+\alpha)}\right]^{\frac{1}{2}} \quad . \quad (22)$$

where

$$\alpha=\frac{M_1-(\pm M_2)}{M_1+(\pm M_2)},$$

and the other terms have the usual meanings.

If M_2 is a bending moment less than M_1, the stress variation across the section at the notch is as shown in Fig. 17. The stress concentration at the notch causes a slight shift of the neutral axis of the section, but the amount of shift is small if the depth of the notch is not large relative to the depth of the section at the notch.

(To be continued)

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Effect of New Materials on Engineering Progress

By DR. WILLIS JACKSON, F.R.S.

In his Presidential Address, delivered on September 3rd, to Section G of the British Association for the Advancement of Science at its Oxford meeting, Dr. Jackson indicated by reference to a number of examples the great part played in engineering advancement by new materials. The address is printed here nearly in full. It opens with a discussion of the improvement of power and submarine cables through the discovery of polythene ; describes advances made in the design of power transformers through the improvement of steel sheet, through the development of the powder core technique and through the development of the ferrites. The valuable properties of germanium transistors are next discussed ; and the lecture concludes with references to the new materials for the generation of nuclear power.

THE most obvious way in which progress can occur is by the steady improvement within a well-established technique of the materials employed in it.

One such technique in electrical engineering is the transmission of electrical power from one point to another by means of cables. This power may be for industrial purposes at a frequency of 50 c/s when the transmission voltage may reach a value of 275,000V and the power involved many tens of thousands of kilowatts ; or it may be associated with the transmission of telegraph, telephone or television signals at voltage and power levels which are relatively minute but at frequencies which in the case of television extend up to several million cycles per second. The construction of the cables employed for these two purposes is widely different due to the differing nature of the problems associated with high voltages in the first and with high frequencies in the second, but in both cases the major problems have been associated with the materials used for insulating the cable conductors from each other.

I will deal first with power cables. The last quarter of the nineteenth century saw the development of central power stations for generating electricity to be distributed to consumers in the surrounding countryside. Distribution was first carried out by means of copper conductors suspended overhead on porcelain or other insulators. However, the orderly Victorian mind reacted against the unattractive appearance of these overhead systems, and it was perhaps this circumstance which led to the early establishment of the power cable industry in this country. The conductors of a cable are surrounded by a material which serves the dual purpose of affording mechanical separation and support and of preventing current leakage from one to the other. Gutta-percha was already established as an insulant for submarine telegraph cables and this material was therefore tried for power cables together with vulcanised rubber and vulcanised bitumen.

These materials proved reasonably satisfactory so long as the transmission voltage was merely the 100 or so volts provided by the early d.c. generators. But the need to distribute electricity over greater distances than this d.c. system permitted required the use of higher transmission voltages. The requirement was met by the introduction of a.c. generators and the use of transformers to step up the generator voltage to a much higher value for transmission. In 1885 Ferranti took the historic and courageous step of designing and laying a 10,000V a.c. cable from a new power station at Deptford to the Grosvenor Gallery in Bond Street, a distance of 5 to 6 miles, in which he employed two concentric copper tubes separated by lapped paper impregnated with ozokerite wax. The cable was made in lengths of 20ft and, in spite of the thousands of joints required, this system operated satisfactorily for more than forty years.

At the time of the first world war the accepted limit of voltage for underground power cable was 22,000, but attempts were being made to raise it to 33,000. After many failures and much experimenting this figure was established as safe, and the operating voltage in this country has since been raised to 66,000 and 132,000 until it has now reached 275,000V.

Yet throughout this extended development, and notwithstanding the very wide range of new synthetic insulating materials which have become available during the past twenty years, lapped paper has remained the basic constituent of the insulation, and indeed the impregnated paper cable is still the only form of cable which can be seriously considered for the very highest voltages. From some points of view this might appear surprising and be thought to suggest too conservative an attitude on the part of cable manufacturers, but it may also be regarded as a tribute to the ingenuity of these manufacturers in overcoming the limitations of paper by careful choice of its constituents and methods of processing ; by the steady improvement of the impregnating mineral oils which replaced wax around 1912 ; and by the introduction of new techniques such as the application of pressures up to 200 lb per square inch to the impregnating oil for the purpose of preventing ionisable voids within the insulating structure—the primary cause of breakdown. In consequence the permissible operating temperature has been doubled, the operating electric stress has increased more than eight times and the power-factor loss in the insulation has been reduced very considerably.

It has already been mentioned that the first cables of importance were those used for submarine telegraphy, in which a copper conductor was insulated with a coating of gutta-percha from the surrounding water, which acts as the return conductor. This form of cable remained practically unchanged until about twenty years ago. The demand for submarine telephony had become pressing and ways and means were being sought whereby the electrical characteristics of the existing type of cable could be improved to accommodate the much increased frequency range involved. The problem of long-distance submarine telephony resolved itself into one of producing a cable with sufficiently low electrical losses. The most effective way of doing this was to improve the insulation, and not surprisingly the first step was concerned with refining the well-established gutta-percha.

Then in 1933 there occurred an event of outstanding importance to the submarine cable industry. During the course of researches into the behaviour of gases under pressures of the order of 1000 atmospheres, Imperial Chemical Industries discovered that ethylene gave rise to a white wax-like solid which was quickly recognised as a polymer of ethylene. This material was found to have the right physical properties for submarine cable purposes and of no less importance it exhibited remarkably low electrical losses up to very high frequencies. However, its first important application was not to submarine cables, but in cables to interconnect the transmitters and aerial systems of our early wartime radar installations. The exclusive availability of polyethylene (or polythene) in this country played a vitally important part in helping us to gain the ascendancy in this aspect of our early wartime achievements. With the further development of radar technique which resulted from the introduction of the cavity magnetron operating at wavelengths of only a few centimetres, much of the part which had been played by polythene cables was taken over by other means of interconnection, but its submarine cable application became of increasing significance as the time for the invasion of the Continent approached. It had been realised from the beginning of the planning of this operation that immediate and reliable telephonic communication from headquarters to the bridgehead would be a vital necessity, and with this end in view stocks of cable insulated with polythene were manufactured and stored at strategic points along the coast so as to be available at a moment's notice.

A very important post-war development —to which I will refer again later—has been the incorporation at intervals along the cable of submerged repeaters, their purpose being to provide periodic amplification of the telephone signals. Functionally these repeaters are similar to the valve amplifiers which form part of our radio receivers, but the conditions of operation are much more severe. Their component parts must be capable of long service under conditions which preclude normal servicing and their containers must be sealed at the cable entry and exit points by glands which will withstand the high external water pressure. The inclusion of repeaters at intervals of 40 to 50 miles along the cable length enables all the advantages of shortness to be obtained in cables of almost unlimited length. Several such cables insulated with polythene have been laid during recent years, and it is to be hoped that the start of the projected transatlantic telephone cable, to be made of the same material, will not be long delayed.

My concentration on polythene, and indeed on only a small region of its sphere of application, does scant justice to the immense progress which has been made during the past twenty years in the development, production and use of the class of synthetic materials known as plastics. But the range of types and the variety of applications of these materials is bewildering even to the well-informed, and I must pass to my next example.

I have already referred to the transformer as the device by which the voltage of an electrical supply is changed from one value to another. In its simplest form it comprises two coils of wire, the turns ratio of which corresponds to the voltage ratio desired, wound on a continuous core of

magnetic material, and was invented in the early 1830s by Faraday as one of the means by which he demonstrated his discovery of the principle of electromagnetic induction. It remained unused and undeveloped, however, until the change from d.c. to a.c. generation towards the end of the century, but it has since become a major item of equipment in our system of electrical supply, and single power transformer units are now in operation rated at 190,000kVA, and others have been constructed for voltages as high as 350,000V.

Such large transformers operate at full-load efficiencies as high as 99·4 per cent, but this figure by no means satisfies the transformer designer, since an increase in efficiency would not only result in a substantial saving of generated power in the country as a whole, but would also simplify the problem of cooling the individual units and therefore reduce their size and cost for a given power rating. The causes of this small, but expensive, inefficiency are the power losses in the resistance of the copper windings, about which the designer can do little, and in the magnetic material of the core. With the help of the steel manufacturers, he has been struggling to reduce these magnetic losses throughout the past fifty to sixty years. In the early days of power transformer manufacture the core material was mild steel assembled in the form of thin sheets* or laminations, and a common experience was for the transformer efficiency to decrease progressively with time in service due to a progressive increase in the magnetic power loss in the steel—what was called magnetic ageing—until the resulting excessive temperature rise caused electrical breakdown of the windings.

This unhappy state of affairs led to an extensive search for an improved quality of sheet steel and a decisive advance occurred with the discovery by Robert Hadfield and his colleagues in Sheffield around 1900 that the addition of a few per cent of silicon to steel of low carbon content reduced the magnetic losses by several hundred per cent, and also eliminated the troublesome phenomenon of magnetic ageing. Steady improvement has continued since this important discovery, notably by the almost complete elimination from the steel of small proportions of undesirable impurities such as sulphur, oxygen and phosphorus, as well as carbon, by high temperature annealing in hydrogen. In consequence, the last ten to fifteen years has seen a reduction in the magnetic power loss in British electrical sheet steel for comparable operating conditions by some 30 per cent.

During this period, however, a new possibility has emerged from scientific research on single crystals of ferro-magnetic materials, which is now becoming of considerable industrial importance in the above connection. The research showed that single crystals are highly directional in their magnetic properties. For example, the crystals of iron and silicon-iron are of cubic structure and it was found that they magnetise most readily in the direction of the cube edges and exhibit much superior magnetic properties in these, as compared with other directions of magnetisation. Now in transformer cores the magnetic field is directed along the plane of the sheets from which the core is constructed—that is, in the direction in which the sheets have been rolled. It was too much to expect that the sheets could be made as single crystals—though this is not to be entirely excluded as a future possibility—but attempts were soon made to produce silicon-iron sheet material closely approaching the structure of a single crystal by arranging for the tiny constituent crystals to have their cube edges oriented in the rolling direction. This occurs to some extent in the normal hot-rolled sheet referred to above, but it was found possible to achieve a much increased preferred crystal orientation and much improved magnetic properties by following the hot-rolling process with an appropriate sequence of cold rolling and annealing treatments. The new cold-rolled material is already being used extensively in the United States, and is now becoming available in considerable quantities in this country.

The improvement in magnetic properties attained in oriented sheet metal is attended by a number of applicational difficulties which are not yet fully overcome, but there is no doubt that the availability of this material will permit a further step forward in transformer technique.

In parallel with this progress on the power transformer side a rather more spectacular advance was occurring in the development of magnetic materials for telecommunication applications. Since the values of electric current arising in these applications are very small compared with those in power engineering, the magnetic materials employed are usually operated at much smaller magnetising forces. The potentialities of the nickel-iron alloys in this respect began to emerge in the pioneer work of Hadfield, which led him to the development of the silicon-iron alloys mentioned above. By the early 1920s the use of nickel-iron alloys was well established in telecommunication equipment, and later work took the form of studying the effects of adding further elements such as molybdenum, chromium and copper until in the mid-1940s there was produced in America an alloy of iron, nickel, molybdenum and manganese, known as Supermalloy, of quite exceptional properties. These various alloys were produced in sheet or strip form, and used in much the same manner as in power transformer construction, though the overall sizes bore no comparison. However, an adequate reduction of the eddy current component of magnetic loss at frequencies of several million cycles per second demands a much finer subdivision of the core material than is possible with the laminated construction. The requirement was met by preparing the magnetic alloys in powder form, coating the individual particles with an insulating film and compressing the powder to the desired core shape. Even this advanced, powder core, technique is now being superseded through utilisation at long last of the well-known magnetic properties of the iron oxide, Fe_3O_4. During the recent war the effect of replacing one of the iron atoms by the atoms of other elements such as nickel, zinc, manganese, &c., was studied extensively in Holland, and there resulted a very important new class of magnetic materials, known as the ferrites. These materials have an extremely high electrical resistivity compared with metals, so that it is not necessary to grind them to a powder and insulate them as in the powder core technique in order to reduce eddy current loss. They show promise of finding extensive application in the further development of telecommunications.

I come next to a quite different way in which progress can occur—by the discovery, and recognition of the potentialities, of some special property of a material leading to the evolution of a new engineering technique.

A good example of this is afforded by the post-war discovery and development of the germanium crystal triode, known as the transistor ; an amplifying device capable of performing most of the functions of the thermionic triode valve but much simpler in construction and much smaller in size and having the great advantage for many purposes of not requiring a heated cathode as its source of electric charge carriers.

To introduce this discovery I must take your mind back to the early days of wireless telephony, when the detector employed consisted of a small crystal of natural silicon and a contact wire, or cat's-whisker, of tungsten. Some of you will remember that the chief characteristic of these early crystals was the need for incessant probing with the cat's-whisker to find a sensitive point on the crystal surface and the ease with which the point could be lost on the least vibration. With the advent of the stable thermionic valve, the crystal fell into disuse, to the regret, I think, of many, for with it went much of the early fun of wireless.

When, however, during the early 1930s research work was started on the generation of oscillations of centimetre wave-lengths, with corresponding frequencies in the hundreds of megacycles, the lack of a thermionic valve capable of operating as an efficient detector at these frequencies caused a return to the crystal detector. In 1940 the invention of the cavity magnetron made large centimetre-wave powers available and the crystal was introduced into service radar equipment as a matter of necessity notwithstanding the grave dangers associated with its lack of stability. It was regarded, of course, as no more than a stop-gap which would shortly be superseded by a thermionic valve, but in fact no such suitable valve became available and manufacturing methods were developed during the early war years which made the silicon crystal detector as stable and rugged as a valve.

During the course of this early development work, the study of other materials established that silicon was in fact the best for use at the highest frequencies available : but it was found to be markedly inferior to germanium, an extremely rare metal in purified form, in its ability to withstand voltage in the high resistance direction of operation and was therefore relatively easily damaged by strong signals—the process known as burn-out.

In consequence, although germanium did not replace silicon in centimetre-wave detectors its ability to withstand high reverse voltages began to stimulate a demand for germanium rectifiers for low frequency applications as an alternative to the thermionic valve, copper oxide and selenium rectifiers in widespread use.

The first problem was, of course, to produce this scarce and inaccessible metal in adequate quantities. It was found to be present in concentrations around 0·01 per cent in some of the ores from which zinc and cadmium are extracted and also in small proportions in the flue dust from certain classes of British coal. The second problem arose from the observation that the merits of germanium as a rectifier material were markedly dependent on its purity and that the presence of certain kinds of impurity atoms in concentrations of less than one part per million seriously affected its performance.

The solution of these extraction and purification problems has involved the expendi-

* These sheets are insulated from each other electrically to reduce the eddy current component of the loss.

ture of very extensive effort and called for great metallurgical skill and ingenuity.

However, important though it is in itself, the development of the germanium diode proved to be only the forerunner to the revolutionary discovery in 1948 of the germanium triode. The construction of this device in its original point-contact form is illustrated in Fig. 1 (*a*), and a simple equivalent electric circuit is drawn in Fig. 1 (*b*).

It has three electrodes of which the so-called emitter and collector electrodes consist of cat's-whisker contacts located a few thousandths of an inch apart on one face

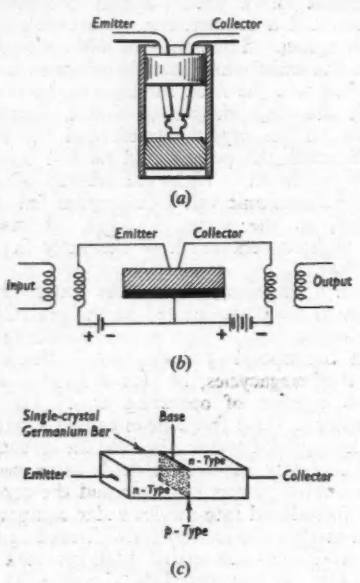


Fig. 1

of the germanium crystal, and the third, the base, electrode covers the other face. Although close comparison with the thermionic triode is not altogether profitable, these electrodes may nevertheless be thought of as corresponding to its cathode, anode and grid electrodes respectively. It is not possible here to explain the mechanisms within the germanium which govern the operation of the device, but what happens externally is that a variation of electric current in the emitter circuit due to an applied signal voltage produces a sympathetic current variation in the collector circuit from which considerable voltage and power amplification of the signal can be obtained. In some respects this form of transistor is still in the development stage but it is now in commercial production and is beginning to find many varied applications. And yet, as evidence of the rapidity of present-day scientific and technological progress, it is already in process of being superseded by the junction-type transistor illustrated in Fig. 1 (*c*), which has the important advantages of being less "noisy," of permitting amplification over a wider range of frequency in the input signal and, because of the greater surface area of its electrodes, of handling much increased signal power.

A few remarks are necessary about the regions of the germanium marked *n* and *p* in Fig. 1 (*c*). Those marked *n* contain small proportions, of the order of only a few parts in one hundred million, of impurity atoms such as antimony or arsenic which endow the germanium crystal lattice with one excess electron per added impurity atom. The excess electrons may be regarded as "free" to move about within the lattice, and the electrical conduction in the *n* regions takes place by means of these electrons. The *p* region, on the other hand, contains a similarly small proportion of atoms such as indium or gallium which produce an electron deficiency of one electron per impurity atom—so-called positive holes—and current flow in it is known as positive hole conduction.

The production of these junctions starts with the preparation by successive recrystallisation processes of highly purified single crystals of germanium, which are cut into thin wafers and these into tiny pellets. For n-p-n junctions the pellets must initially be of p-type germanium throughout and the n regions are then prepared by diffusing into them by thermal processes the appropriate kind and concentration of impurity atoms.

The volume of experimental forms of n-p-n transistors is of the order of only 1/500 cubic inch, as compared with $\frac{1}{8}$ cubic inch for present-day sub-miniature thermionic valves and 1 cubic inch for miniature valves, and the device has the added merit, already mentioned, over the valve that it does not incorporate a heated cathode and therefore avoids the electrical supply needed by the valve for this purpose. These are great advantages for such purposes as submarine cable repeaters and guided missiles, where the reduction of the size of components and of the operating electrical supplies to a minimum are of vital importance, and also in the construction of complex equipments such as electronic computers incorporating in their existing form many thousands of valves. Much remains to be done before the junction transistor becomes as reproducible in characteristics and as versatile as the valve, but a very important future lies ahead for it. There is no reason to doubt that more intricate devices analogous to multi-electrode thermionic valves will be developed in due course, and that the power which they are capable of handling will be increased considerably from its present level. This is evident from the rapid progress being made in the development of n-p junction diodes for power rectification purposes.

As a second illustration of the emergence of a new engineering technique from the discovery of a special property of a material, I move to a quite different field, that of the conversion of the nuclear energy of uranium—an element of almost insignificant engineering importance less than fifteen years ago—into electrical energy, and I will try to indicate how the practicability of this conversion is dependent on the use of other materials also possessing special properties, though of a different kind.

This new branch of engineering has arisen from the discovery that the nucleus of the uranium isotope of atomic weight 235, written U_{235}, can be split by the entry into it of an uncharged neutron of suitable energy, and that in the disintegration other neutrons are made available to continue the process. The aggregate mass of the fission products is less than that of the original U_{235} atom and this mass difference appears as free kinetic energy of total magnitude around 200 million electron volts per fission. The average number of neutrons produced per fission is $2{\cdot}5 \pm 0{\cdot}1$, and their median energy is about 1,000,000 electron volts.

For the purpose of an atomic bomb the ideal is for all the fission neutrons to produce further fission in a chain reaction, but in a nuclear reactor to be used, in part at any rate, for external power generation over long periods of time, the fission rate must not be cumulative, but be kept substantially constant. The reactor will continue in operation so long as one of the neutrons ejected per fission produces further fission; that is, if, on the average, not more than 1·5 are used up in other ways.

Natural uranium contains only 0·7 per cent of fissionable U_{235}, the remaining 99·3 per cent being the isotope U_{238}, and with this material as fuel considerable ingenuity is required to establish and maintain the reaction. Thus some of the ejected neutrons come into collision with and are absorbed by the surrounding U_{238} atoms, with the resulting production of the important element plutonium, while others are absorbed unprofitably in the materials constituting the structure of the reactor. It is essential for one neutron per fission to survive absorption in these ways if the fission process is to continue.

Now the statistical probability of the fission capture of neutrons by U_{235} is greatest when the neutrons are of quite low energy, around 0·03 electron volt, so that the fission neutrons must be slowed down to this energy

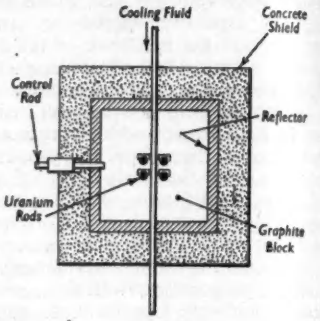


Fig. 2

value from the million or so electron volts which they possess initially. To do this the uranium fuel is arranged in the form of an array of parallel rods and is surrounded by a medium known as a moderator in the manner illustrated in Fig. 2. The neutrons undergo successive collisions with the atoms of this medium, and lose energy in the process, before diffusing back into the fuel elements at energies at which the probability of fission capture by the scarce U_{235} is high.

The essential requirements of the moderator material are that it should slow down the fission neutrons to the desired energy in a minimum number of collisions and with minimum loss of neutrons in doing so, and these demand that it shall be composed of atoms of low atomic weight and low neutron absorption characteristics. The choice so far has been between three substances—highly purified graphite; light water, H_2O; or heavy water, D_2O, deuterium being the heavy form of hydrogen.

Of these, heavy water is better in both respects than graphite, and to such an extent as to reduce by a factor of ten the minimum size of operable reactor. On the other hand, heavy water does not provide the structural support for the fuel elements afforded by graphite blocks and is much more expensive. It is not many years since this substance was a scientific luxury made with difficulty and in very small quantities, and even now after extensive large-scale research and development work the cost of its production by successive electrolysis of ordinary water is around £75,000 per ton. During the last few years a search has been made for a more economic means of producing it and a combined New Zealand - United Kingdom team has recently evolved a method of utilising the steam which pours from the ground in the volcanic regions of New Zealand.

Light water is, of course, vastly more economical than D_2O in itself, and being lighter slows down neutrons more effectively;

but its neutron absorption, and therefore the neutron loss, is several times higher. This demands the use of enriched uranium fuel—that is, fuel in which the U_{235} proportion is above the figure for natural uranium—and the cost of producing this enriched material is at present so high as to leave uncertain whether the use of light as against heavy water would in fact be economically advantageous.

The energy released in the fission process expressed in electrical terms amounts to some 22,000 units of electrical energy (kilowatt hours) per gram of U_{235}, and the purpose of the reactor cooling system shown in Fig. 2 is to remove as heat such of this energy as is not absorbed in other ways and at a temperature which is safe for the reactor and also serviceable for power generation purposes. Five substances have been used or are under consideration as the cooling medium—two of them, helium and carbon dioxide, are gases, and the others are liquids, namely, light water, heavy water and liquid sodium or sodium-potassium alloys. The power reactor now under construction in Cumberland uses graphite as moderator and carbon dioxide at several atmospheres pressure as cooling medium. The extensive use of liquid sodium or one of its alloys no doubt lies many years ahead but it has several advantages over the other possibilities, notably that of permitting a much higher operating temperature and therefore an improved thermal cycle in the power generator unit. I do not find it easy, remembering my schoolboy experiments with small pieces of sodium, to think of it as an important engineering material of the future, but it seems certain that this will prove to be the case.

But perhaps the most important materials problem in reactor design is that of encasing the fuel elements so as to prevent contact between the uranium and the cooling medium. The metallurgical requirements for the sheathing material are extremely severe and restrictive. Thus, it must be capable of fabrication in the form of thin-walled tubes; have adequate strength at the elevated temperature of the fuel elements to withstand the thermal and mechanical stresses imposed on it; its mechanical properties must not deteriorate under the intense neutron bombardment to which it will be subjected; it must not corrode as the result of contact on one side with the fuel elements and on the other with the cooling medium; and it must exhibit low neutron absorption. As already mentioned, the latter imposes the necessity for a metal of low atomic weight, and the designer finds his choice limited to such metals as aluminium, magnesium, beryllium and zirconium. Aluminium has been used in low temperature reactors for research purposes, but, as with magnesium, its melting point is too low and its mechanical properties inadequate for future power reactors. Considerable attention is therefore being given to the production of beryllium and zirconium, and it is again illustrative of the pace of scientific and technological advance that whereas the latter metal hardly existed some five years ago it is now being produced in the United States in highly purified crystal form at the rate of tons per month.

ATOMIC ENERGY DEVELOPMENT IN INDIA.—According to *Indian Trade and Industry*, the Government of India has decided to create a separate Department of Atomic Energy under the direct charge of the Prime Minister, Mr. Nehru. Dr. H. J. Bhabha, chairman of the Atomic Energy Commission, will act as secretary of the new department. The new department will be located in Bombay and will take over from the Union Ministry of Natural Resources and Scientific Research all matters connected with atomic energy.

Fourth European Machine Tool Exhibition

No. 1

THE fourth European Machine Tool Exhibition, sponsored by the European Committee for Co-operation of Machine Tool Industries, has been organised by the Unione Costruttori Macchine Utensili, of Italy, and is to be opened at Milan on Tuesday next, September 14th; it will remain open until Thursday, September 23rd. The number of exhibitors has this year increased to 842, and they will occupy a stand space of nearly 406,000 square feet in eight halls in the Milan Fair grounds. The largest numbers of exhibitors come from Germany and Italy, with 298 and 241 firms respectively. Forty-four British firms will be showing their products, whilst the other countries to be represented will include: France, eighty firms; Switzerland, seventy-four firms; United States, thirty-one firms; Belgium, twenty-five firms; Sweden, nineteen firms; and Austria, thirteen firms.

Preliminary information received from exhibitors indicates that machine tools of all classes will be widely represented, together with large numbers of accessories and ancillary equipment. A certain number of new designs will be shown, and whilst many of the machines are similar to those exhibited in previous years, they generally incorporate improvements designed to increase their working accuracy, facilitate operation and improve efficiency in metal removal and manipulation. The size of the exhibition is such that it would be quite impossible for us to deal with more than a few of the new machines, and those shown this year for the first time.

COVENTRY GAUGE AND TOOL COMPANY, LTD.

The group of grinding machines on the stand of the Coventry Gauge and Tool Company, Ltd., of Coventry, will include one of the firms "two-way" high-speed tap grinding machines. In the two-way grinding action of this machine the bulk of the stock is removed in the first pass, followed by a light finishing pass in the opposite direction. By this method of grinding taps any "barrelling" due to the unavoidable spring of the tap blank under grinding pressure is automatically corrected. The machine is largely automatic in operation and, as can be seen from the photograph reproduced in Fig. 1, it has a hinged sheet steel hood to prevent coolant splash during grinding. It grinds threads up to 2in diameter up to 4in long at one setting and takes work up to 12in long between centres. Taps with two to twelve flutes can be ground with pitches from eight to sixty threads per inch. In the automatic cycle of operations, once the machine has been loaded and started the wheel advances rapidly to the grinding position, whilst the hood closes and twin high-pressure jets of coolant are directed on the work; the work spindle rotates and traverses the tap past the grinding wheel; when the work reverses the wheel is advanced by 0·002in for finish grinding on the return stroke; at the end of the cycle the work spindle stops and the wheel backs out for reloading as the coolant supply is shut off and the hood automatically rises.

The cast iron cabinet base of the machine contains the gearbox, electrical control gear, and lubricating unit. The wheel head has two dynamically balanced motors, one of 3½ h.p., 1430 r.p.m., for grinding drive, and one of 1½ h.p. at 700 r.p.m. for dressing and crushing drive purposes. The wheel head assembly can be swivelled up to 10 deg. either side of its vertical position to incline the wheel in the required plane for either left or right-hand helix.

Collets up to ⅜in capacity can be accommodated in the hollow spindle of the work head, in which backlash compensation is provided for two-way grinding. In place of the conventional lead-screw and nut there is a leader and nut situated at the back of the headstock, which can be changed for the required lead. A side cut motion provided in the headstock enables the work slide to be displaced axially in relation to the wheel, and this facilitates the alignment of the ribs of the wheel into a pre-roughened thread.

The gearbox and wheel feed assembly is built into the front apron of the machine and pick-off gears can be selected to give the required work speed range and rapid reverse. A control is incorporated to enable the work spindle to reverse at the same speed as the forward speed, if so desired. The relief cam in the gearbox can be reversed on its mounting for right or left-hand relieved work. Relief change gears can be selected in accordance with the number of straight or spiral flutes between two and twelve. A large handwheel is used to vary the depth of cut, whilst a cam is used to operate the automatic feed-in in conjunction with the work cycle.

The firm recommends the use of its automatic multi-ribbed wheel crusher for dressing the grinding wheel on this machine. With this unit the roller is fed down at a predetermined pressure and, apart from simple presetting, its crushing action is entirely automatic.

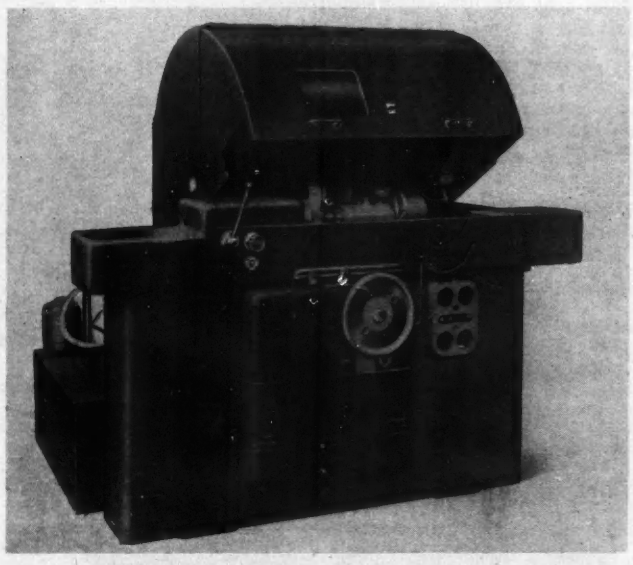


Fig. 1—"Matrix" high-speed two-way automatic tap grinding machine

GEORGE FISCHER, LTD.

The group of copying lathes to be seen in operation on the stand of George Fischer, Ltd., Schaffhausen, Switzerland, will include the interesting twin, opposed, headstock arrangement of the firm's model "KDM-28/7" chucking machine, which is illustrated in Fig. 2. On this two-headstock machine it is possible to do such work as the simultaneous turning of inner ball bearing races on one spindle and the outer races

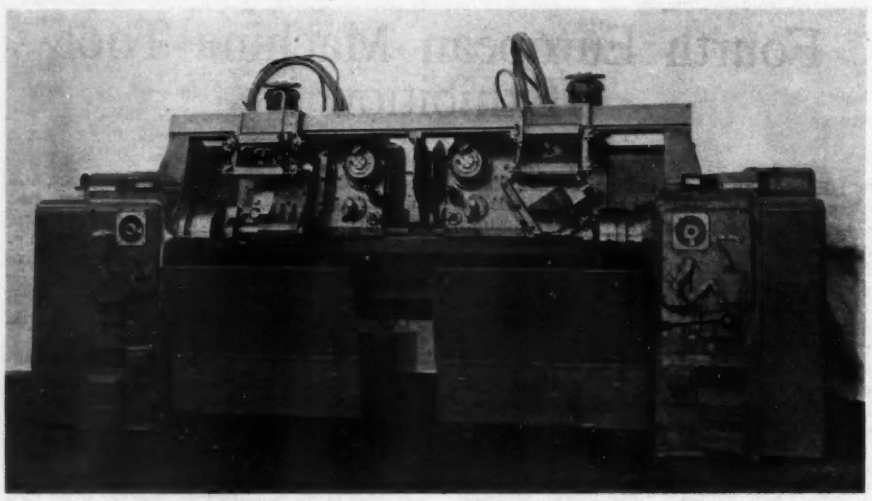


Fig. 2—Automatic copying chucking lathe with twin headstocks. Machine tooled at one end for boring the inner rings and at the other end for machining the outer rings of ball races

on the other spindle. Whilst one-half of the machine is operating automatically, the finished component can be unloaded and replaced by a blank at the other end.

Each headstock is designed to turn work from 4·7in to 14in diameter and up to 6·7in long. The twelve spindle speeds range from 65 to 355 r.p.m. and an infinitely variable hydraulic feed gives from 0·005in to 0·035in per revolution of the spindle. A hydraulically operated chuck is fitted on the spindle which is bored 3·5in diameter.

The copying slide of each headstock is mounted on the overhead feed carriage and it can be set at angles of 60 deg., 90 deg. or 125 deg. to the axis of rotation. At the 60 deg. and 125 deg. slide settings right-angled shoulders can be turned, and at the 90 deg. setting spherical profiles. A means of automatic turning sequence control is fitted. In this mechanism an interchangeable sequence control valve is used in a hydraulic system, and at the end of each motion this valve rotates a certain amount and starts the next motion. A separate control valve is required for every operating sequence, and the makers state that a small selection of these valves is sufficient to cover most ring-shaped components. The inclusion of an automatic swivelling template holder makes it possible to take two cuts, one after the other, from two different templates without the need for intermediate adjustment.

One of the same firm's model "KDM-7/50" copy turning lathes, equipped with a multi-cut recycling device, to be shown is fitted with the new automatic loading and unloading device illustrated in Fig. 3. With this device the machine is fed with blanks from a magazine situated above the headstock and its complete cycle up to the ejection of the finished component is automatic.

In the sequence of operations when the machining operations on the first component have been completed the work driver or chuck releases the work piece and the tailstock retracts. A lifting device picks up and deposits the component in a box, and at the same time a jaw on the feed carriage grips a blank in the magazine. As the feed carriage moves over, the blank is pulled sideways out of the magazine and located above the space between the centres. The blank is then lowered between the centres and the advance of the tailstock sets it in the work driver, where it is automatically clamped. The loader meanwhile releases itself and is returned to its starting point ready to pick up the next blank. The multi-cut recycling mechanism is then automatically engaged for the machining operation. At the end of a run of work when the magazine is empty the main spindle drive is automatically stopped.

H. A. Waldrich G.m.b.H.

One of the interesting large machines to be exhibited is the 750mm by 6500mm roll grinder made by H. A. Waldrich G.m.b.H., Siegen, Westphalia. The photograph reproduced in Fig. 4 shows that this machine has a bed with an inclined rear slideway, a design first used by this firm for its machines some six years ago. This inclined rear slide arrangement not only increases the rigidity of the bed but it also provides an effective means of supporting the tailstock and work steadies in two planes.

The main headstock drive in the heavier machines of this design is transmitted through a gearbox from a variable speed motor, the lighter machines being fitted with P.I.V. gearboxes. In the heaviest roll grinders where a particularly high starting torque is encountered, rotation of the spindle is started by a separate high induction motor. At a predetermined speed the main motor drive comes into effect and the starting motor is switched off. By using this form of spindle starting the makers state that savings can be made in the installed power capacity.

The grinding head is mounted on a saddle which moves on separate ways parallel to the main bed of the machine. This saddle is com-

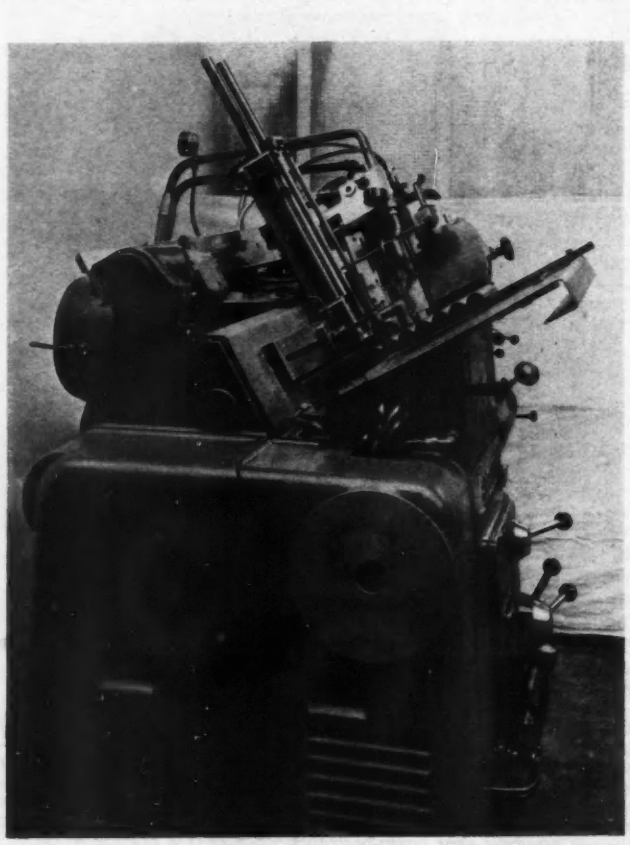


Fig. 3—Copy turning lathe fitted with multi-cut recycling mechanism and automatic loading and unloading device

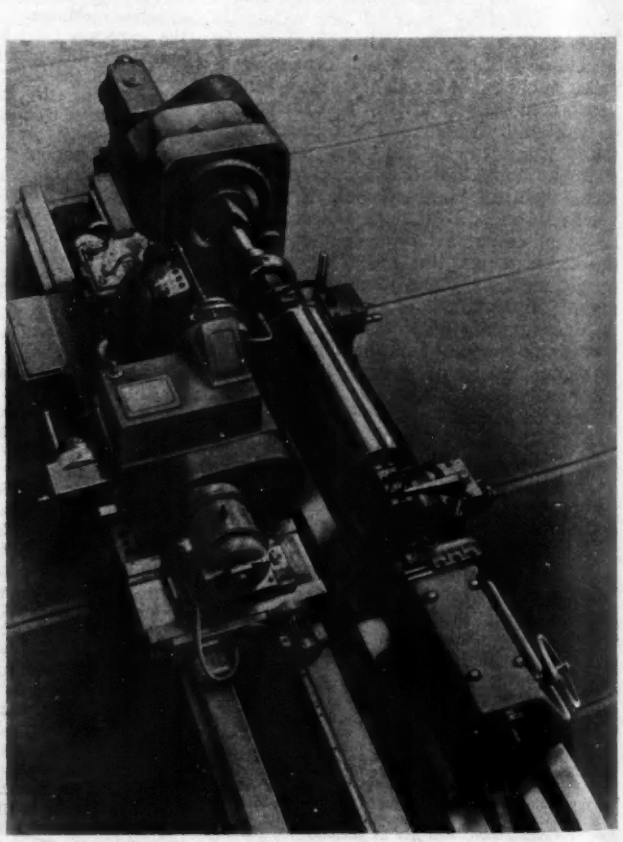


Fig. 4—Heavy Waldrich roll grinder

plete with a seat for the machine operator and the controls are arranged in such a way that an unobstructed view of the work is obtained. The grinding spindle is mounted in plain journal and thrust bearings in the completely enclosed headstock. Self-adjusting, spring-loaded pressurised bearings are fitted, and in the event of interference of the flow of lubricating oil the grinding wheel is automatically disengaged from the work and the main drive stopped. A motor-driven gearbox on the saddle gives eight feed rates and a fast traverse speed. The grinding head is mounted on a vee and flat slide and is moved along this slide for coarse in-feed adjustments. Fine in-feed movements are made by tilting the grinding head on its saddle about its longitudinal axis.

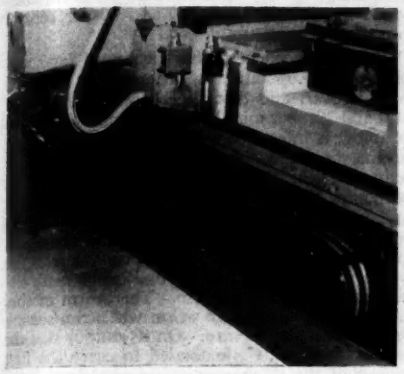


Fig. 5—Chain supporting power and coolant supply lines to saddle of Waldrich roll grinding machine

For form grinding rolls the motion of the grinding wheel is imparted by a rotating template through a system of levers to the head-tilting mechanism. To produce sinusoidal roll profiles a circular template is used.

A point of particular interest on the machine to be shown is the method of connecting power lines and coolant and other supplies to the movable saddle. The power lines and coolant supplies are taken through flexible cables and tubes which are supported on a chain, as shown in Fig. 5. This chain consists of two parallel rows of links connected by drilled bridge pieces, and the cables resting in the channel formed by the links are relieved of any stresses and protected from damage. The chain links are so designed that the minimum radius of curvature is sufficient to prevent kinking of the supply cables. The bridge pieces across the links hold the cables in position as the saddle moves along the machine.

A. A. Jones and Shipman, Ltd.

A prototype tool and cutter grinding machine to take work up to 28in long between centres and 14in diameter is to be exhibited by A. A. Jones and Shipman, Ltd., of Leicester.

The table of this machine (Fig. 7) is mounted on a central spigot and bush on its slide and, using a locking clamp at each end, it can be swivelled up to 8 deg. each side of zero for long tapered work. When it is required to grind acute tapers the table can be swivelled up to 90 deg. in the left-hand direction and 45 deg. right-hand, using double locking on a central facing. The front of the table is a true straight-edge, to which the cutter head and accessory table equipment are pulled up in alignment by bolts fitted in an angular tee slot in the table top. The table slide is carried on bush roller chains, which give free effortless movement. The table can be operated either by direct push and pull or from various positions at the front and rear of the machine. The traversing screw of the cross slide on which the table slide is mounted can be operated by hand wheels at the front or the rear of the machine.

The spindle of the wheel head is arranged for a central drive through a belt from a 0·95 h.p. motor mounted at the bottom of the pillar, and it takes a grinding wheel at each end. The wheel head pillar can be swivelled to any required angle over 260 deg. and it has a vertical adjustment up to 7¾in above centres or 2¾in below centres. Its elevation is effected by large hand wheels situated on each side of the machine and provided with adjustable dials graduated in 0·001in increments.

A universal cutter head supplied with the machine is adjustable in centre height to allow a swing between 8in and 12in. Its large hollow spindle is mounted on ball bearings and has one end bored to No. 50 International Standard taper 2¾in largest diameter, the other end being bored to No. 12 B. and S. taper. An indexing drum can be fitted on the spindle to give accurate spacing and, if required, the head can be arranged for motor drive. The right-hand centre tailstock has a lever-operated sleeve carrying a Morse taper centre, and the left-hand tailstock is fitted with a setting dial to facilitate setting of clearance and rake angles.

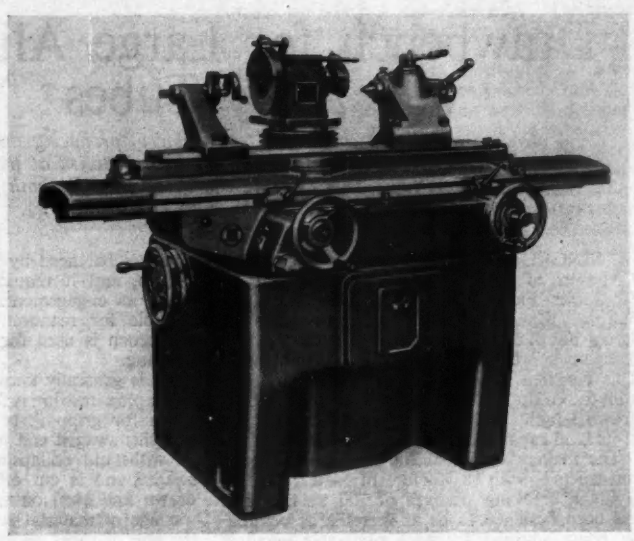


Fig. 7—Cutter and tool grinding machine for 14in by 24in work

Heidenreich and Harbeck

One of the gear cutting machines made by Heidenreich and Harbeck, of Hamburg, and distributed in this country by the Sykes Machine Tool Company, Ltd., of London, is shown in Fig. 6. This machine is designed to produce gears up to 23½in diameter and 2¾ D.P. It works on the double-ram generating principle and is hydraulically operated.

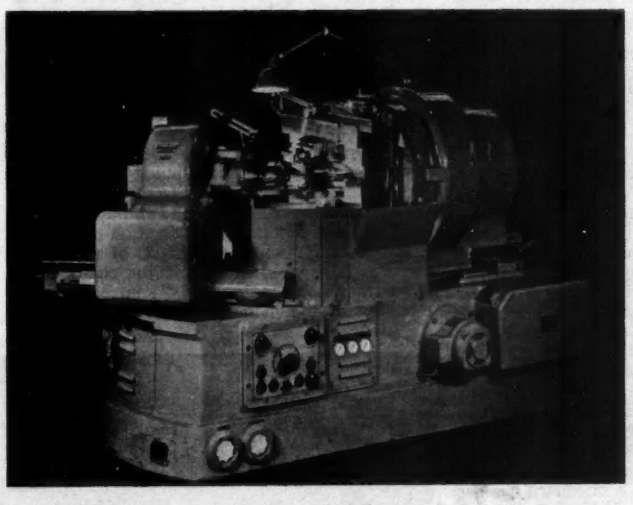


Fig. 6—Gear cutting machine for gears up to 23½ in diameter and 2¾in d.p.

When cutting gears from a blank on this machine the cutter is fed in radially to the tooth depth at plunge feed speed and with the workpiece stationary. On reaching the full depth, the rolling motion starts and the tooth profile is generated. The cutter head then withdraws in rapid traverse to clear the tooth, the gear is indexed and the head returned rapidly to the starting position. If roughed-out teeth are cut, the cutter head travels rapidly to the depth of the tooth, followed by the generating motion.

The machine stops automatically when all teeth on a gear have been cut. The required number of teeth is set on an electric counter before starting and, when the last tooth has been cut, the counter actuates a magnet which controls the oil delivery to the feed cylinder, thus causing the cutter head to withdraw from the work. The finished workpiece can then be removed and a fresh blank can be loaded.

Wickman, Ltd.

In addition to a selection of multi-and single-spindle automatics and one of its optical profile grinding machines, Wickman, Ltd., of Coventry, is to exhibit for the first time two pieces of spark machining equipment. One of the spark machines is the "Erodomatic," which is used for the production of complex die forms in hard materials, and the other is the "Erodosharp" for the reservicing of single-point cutting tools.

The principle of spark machining has already been described in these columns and is now generally known, but the "Erodosharp" machine for tool reservicing is of interest in that the electrode is of circular form and performs the function of a conventional diamond or vitrified grinding wheel. With this machine there is no physical contact between the tool being sharpened and the wheel or electrode during the "grinding" operation. The spark gap between the tool and the wheel is maintained by a film of dielectric fluid of suitable viscosity. The tool is held by the operator on the machine table and drawn across the face of the electrode in the usual way, a coarse, medium or fine finish being obtained by the setting of a three-way switch.

(To be continued)

Human Relations in Industry.—Among the lecture courses being arranged for coming months by the Industrial Welfare Society is one entitled "New Views on Human Relations in Industry." This course will consist of six lectures to be given on Monday evenings, from November 1st to December 6th inclusive, at Robert Hyde House, 48, Bryanston Square, London, W.1. The lecturers include representatives of management and trade union officials. It is stated that each lecture will be brief and "off the record" and will be designed to promote full discussion of the subjects to be covered.

Sulphuric Acid Plant.—A plant capable of producing sulphuric acid at an annual rate of 33,000 tons has been completed at the Stanlow Oil Refinery of the Shell Petroleum Company, Ltd. In this plant hydrogen-sulphide, together with elemental sulphur, is burnt to produce sulphur dioxide, which is passed to a sulphuric acid contact plant. The sulphur dioxide stream is dried and then fed to a four-stage converter, where it is converted to sulphur trioxide over a vanadium pentoxide catalyst, and subsequently absorbed in two towers which produce 98 per cent sulphuric acid and 20 per cent oleum respectively.

Drawbench for Large Aluminium Alloy Tubes

A drawbench which is claimed to be capable of producing the largest diameter aluminium alloy tubes yet attempted has been installed at the works of James Booth and Co., Ltd. This machine can be adapted for both plug and mandrel drawing and produces tubes from 4in up to 17in diameter.

A SINGLE-CHAIN drawbench, with a pulling power of 150 tons, was recently built by Sir James Farmer Norton and Co., Ltd., of Salford, Manchester, to the requirements of James Booth and Co., Ltd., and installed in that company's works at Kitts Green, Birmingham. This bench is designed for drawing aluminium alloy tubes up to 17in outside diameter and 30ft drawn length, and it is claimed to be the first of its kind capable of producing such large tubes.

The makers state that the machine has been constructed with a factor of safety of 5, giving a breaking strength of 750 tons, and it has been designed to be as versatile as possible by being adapted for both plug and mandrel tube drawing. The equipment is particularly designed to reduce the necessity for working with an overhead crane as far as possible, and, by the use of suitable automatic and centralised controls, to be operated efficiently with a minimum of labour. The mandrels used when drawing the largest sizes of tubes on the machine can weigh as much as 5 tons, and it will be appreciated that the provisions for handling such weights with the least possible operational effort introduced a number of problems when designing the machine and its equipment.

The general arrangement of the machine is shown in the drawing on page 357 and in the photographs we reproduce, which were taken after it had been installed in the works of James Booth and Co., Ltd.

The massive cast iron box-section bed of the machine is 50ft long from the centre of the drawing sprocket to the die plate end, and it is constructed of three sections which were rigidly bolted and keyed together on final erection. The central chain groove is planed over its full length, as are the guide faces for the traversing draw carriage, and renewable steel wearing plates are fitted in the bottom of the chain race. The bed is supported on four pairs of box-section cast iron stands, the front pair being fitted with capped phosphor bronze bearings to carry the sprocket wheel shaft. The two middle pairs of stands support the bed sections at the intermediate joints and the back pair at the die plate end carrying the chain return pulley. The slack side of the chain is supported in a continuous steel guide trough fitted with renewable steel wearing plates, and the end of the trough forms a large capacity sump for lubrication of the chain. The chain itself is of five-link construction and is made from specially rolled high-tensile steel. As a safeguard against undue overload three of the link pins are of a lower tensile strength, and are arranged to shear before any damage can be transmitted to the main driving mechanism. A positive stripping device is fitted to the underside of the bed adjacent to the driving sprocket to ensure that the chain does not "cling" to the sprocket on the slack side. Steel ramps are also fitted on the top of the bed at the sprocket end to positively disengage the pulling teeth of the draw carriage from the chain in case of overrun.

For return traverse of the draw carriage back to the die plate after drawing, endless wire cables are attached to both sides of the carriage and run over pulleys at each end of the bed. The capstans for these cables are driven by a push-button-operated independent 8 h.p. geared motor to return the carriage at a speed of 50ft per minute. This is somewhat slower than the conventional drawbench carriage return speed, for the reason that, in this case, the carriage return operation is utilised in loading tubes over the plug rods before drawing.

The heavy drawing carriage of cast steel, to be seen in Fig. 1, is mounted on large diameter flanged runners fitted with ball and roller bearings. A forged steel pivoted, double hook on this carriage which engages with the main chain is balanced by a counterweight and link system, and it requires little manual effort to effect its engagement. The gripping jaws are suitable for mandrel drawing only, although the bench is used for both plug and mandrel drawing.

As is generally known, the orthodox practice when plug drawing is for tube ends to be swaged down for gripping in the draw carriage jaws, and this swaged end has to be sufficiently solid to withstand collapsing under the grip. The swaged end is cut off after a tube is finished drawn and even on smaller sizes of tubes this wastage of material is of much concern. With the size of tubes which this machine is capable of producing this practice would be prohibitive because of the length of tube which would be wasted. For this reason what is termed a "dolly" is used and this is, to all intents and purposes, an end of a mandrel bar which is gripped in the draw carriage jaws. The tube to be drawn is closed down in a squeeze pointing machine to receive the dolly, and the grip of the tube on the dolly is sufficient to permit the tube to be pulled through the die.

The sprocket used to drive the main chain is of high-tensile cast steel accurately machined on the teeth and all working faces. It is fixed to the forged steel sprocket shaft by two fitted taper keys. This shaft is 12½in diameter at the bearing necks and 16in diameter at the centre driving portion. The main drive of the machine, seen in Fig. 4, is by a 150 h.p. squirrel-cage motor and power is transmitted through a magnetic coupling, a two-speed gearbox, an overdriven worm reduction gear, and a double-reduction spur gear on the main driving sprocket wheel. The magnetic coupling plays an important part in the main drive as by controlling the induction between the member coupled to the input side of the drive and the member on the output side varying degrees of slip can be obtained on the output side. Usually, when the hook of the draw carriage is engaged in the moving chain, there is severe shock loading and "snatch" on the tube tag or the mandrel end, resulting in the straining of the various members and in many cases breakage of the tag ends. The slip coupling can, however, be so controlled as to actually stall the chain, although the motor is still running at full speed. Thus, when once the hook is engaged the operator, by control of the rheostat, can bring the chain up to full speed smoothly and rapidly without "snatch" and resultant shock loading. This coupling control can be either hand-operated or automatic to give acceleration over a preset time limit. As this coupling is used in conjunction with a constant-speed squirrel-cage motor, the accelerating period is less than would be required for accelerating the motor itself from idling speed to full speed. The coupling may also be used as a variable-speed member between 100 and 80 per cent of top speed.

The two-speed gearbox is arranged for speed changing by operation of a hand lever mounted on its cover, and through it drawing speeds of 10ft and 20ft per minute are available. A flexible coupling is introduced between the output shaft of this box and the worm shaft of the worm reduction gear. The cast iron casing of the worm reduction gear unit is in two halves, the lower half being extended to form a rigid base plate for the motor, magnetic coupling and two-speed gearbox. The top half of the casing carries the worm shaft, which is in one piece with its hardened and ground worm. This worm meshes with a phosphor-bronze worm wheel rim shrunk on to a cast steel centre. On its output side the worm wheel shaft is extended to carry the first pinion of the double-reduction spur gears, and it is supported on three pedestal bearings. The intermediate reduction gears are also mounted on a high-tensile steel shaft, which is supported on outside pedestal bearings, while the final drive gear is mounted directly on to the sprocket shaft which, in turn, has three pedestal bearings. Both of the pinions are of high-tensile forged steel, while the wheels are of cast steel, the final drive gear being of shrouded construction with cast teeth. This wheel is 10ft 6in diameter by 14in face and 16in wide over the shrouds. All the base plates and pedestal bases are tied together by rigid box-section cast iron foundation plates.

The die plate holder is of particularly strong construction as it has to take the full load of the draw each time a tube is processed. As some of the larger die plates used weigh over a ton special attention had to be given when designing the holder to make it possible to handle such die plates without the repeated use of an overhead crane. In the holder used on the machine, die plates are carried in an open top box having a series of freely mounted rollers in the

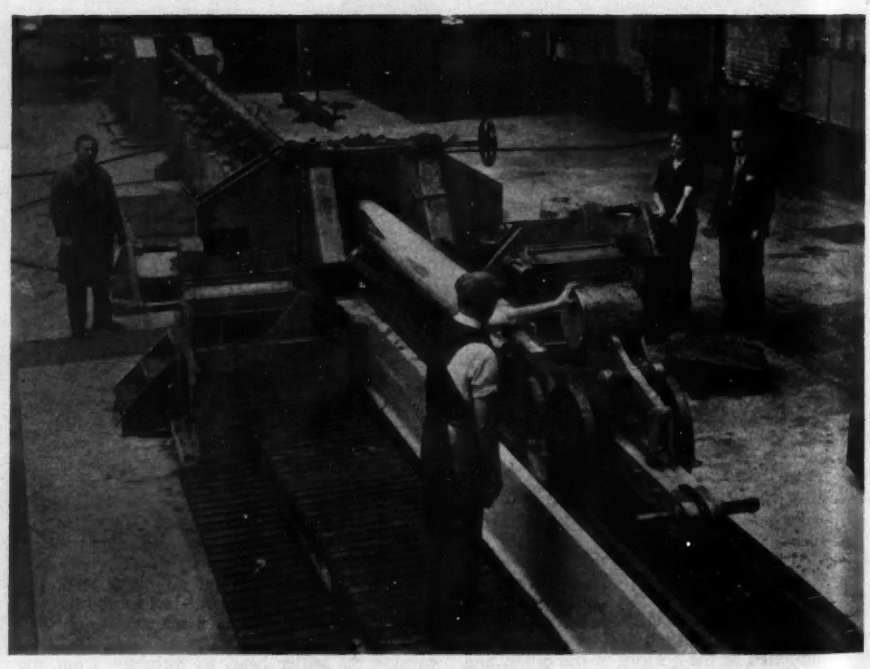


Fig. 1—Draw carriage in operation. The rear support rollers of the die plate holder are advanced to take the weight of the tube and mandrel on completion of draw

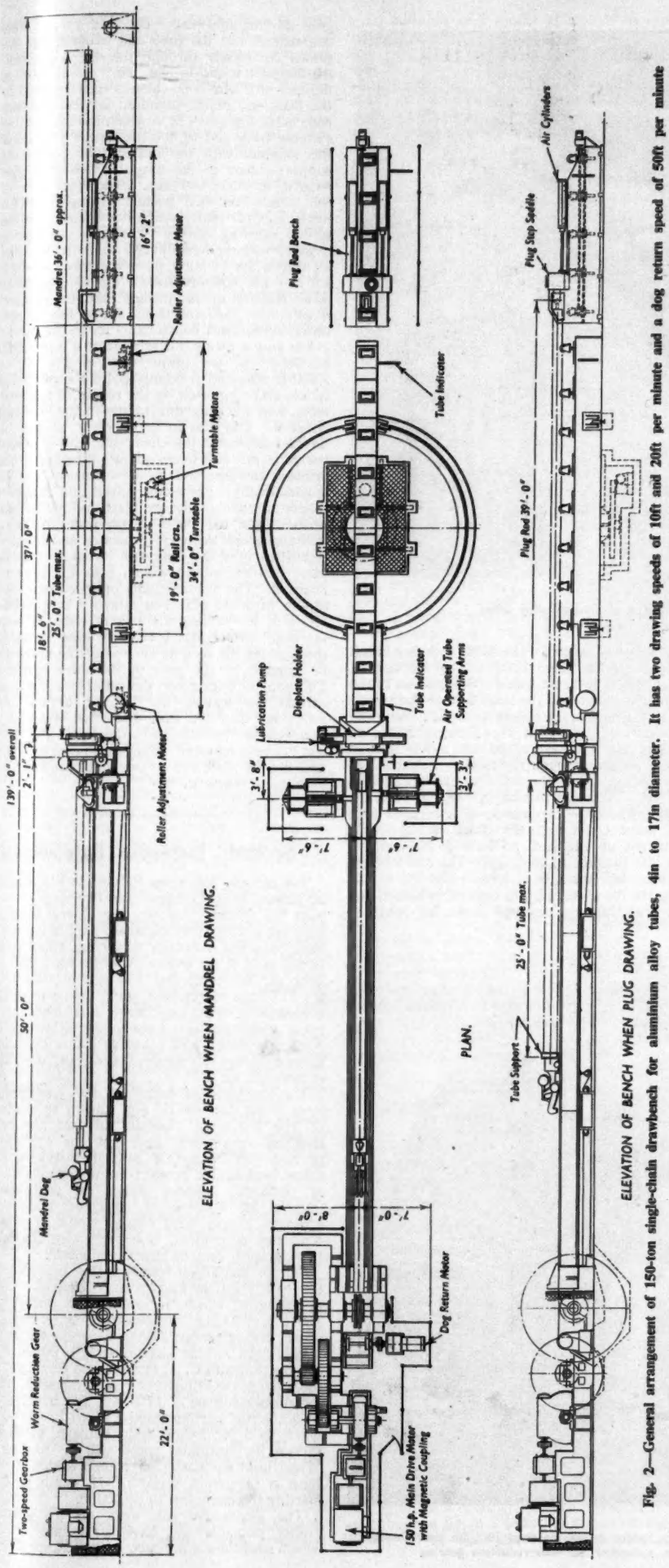


Fig. 2—General arrangement of 150-ton single-chain drawbench for aluminium alloy tubes, 4in to 17in diameter. It has two drawing speeds of 10ft and 20ft per minute and a dog return speed of 50ft per minute

bottom on which a die plate rests. On these rollers a die plate can easily be pushed by hand to one side of the box when it is not required in the drawing position. A tube stripper plate can likewise be pushed from the other side of the box into line with the drawing centre when required for removing a tube from the bar in mandrel drawing. With the die plate at the side of the box, tubes can be loaded on to plug or mandrel bars down the centre of the bench. The die plate holder is provided with handwheel-operated vertical adjustment for aligning the centre of the die with the line of draw.

A three-roll tube stripping attachment is fitted immediately behind the die plate holder. This attachment is used to roll the tube immediately it comes through the drawing die when mandrel drawing. This operation swells the tube slightly by stress relieving, so that the mandrel can subsequently be removed from the drawn tube with comparative ease. The rolls of this attachment are set at about 120 deg. to each other and they can be adjusted radially to cover the full range of tube diameters drawn on the machine. The two top rolls are adjusted by one handwheel through bevels, worm gears and screws, whilst a separate handwheel is used to position the bottom roll.

When drawing large diameter tubes, and particularly when mandrel drawing, it is necessary to support the tube after drawing. For this purpose two rollers mounted on heavy retractable arms are fitted, one on each side, on the die plate end of the bed to support the tube and mandrel as they leave the stripping rolls on completion of a draw. These rollers, which can clearly be seen in Fig. 1, are leather faced to prevent marking of the drawn tube. They are retracted and advanced by large pneumatic cylinders against adjustable stops. When they are retracted the drawing carriage can be positioned close up to the die plate without obstruction. The adjustable stops are fitted with large size-indication plates so that the operator can see at a glance that they are set for the correct tube diameter being drawn.

A turntable back bed has been fitted to support tubes and mandrel bars prior to drawing. Ten profiled rollers on this bed can be individually or simultaneously adjusted for height to suit different diameters of tubes. The two 1 h.p. motors used for roller height adjustment are push-button controlled from the main control desk, and by lever-operated dog clutches on the turntable itself. Large dial indicators are provided to show the operator the height setting of the rollers.

The turntable, is a fabricated steel structure 34ft long, and it rotates on a 19ft centres circular track with ball and roller bearing runner wheels. The table is rotated by spur gears driven from a worm reduction gear let into a pit in the floor. Its drive is by two motors, one being of 4 h.p. for main rotation at 2 r.p.m., and the other a 1 h.p. geared motor which is used for inching adjustment. These motors are interlocked to prevent simultaneous engagement. With the exception of this actual turntable rail track the whole of the floor is plated to leave a clear floor without any pits or other obstructions round the machine.

The plug rod bench, which is situated at the outermost end of the turntable, can clearly be seen in Fig. 3, and it is of very heavy construction to take the full plug rod load. It has a close-grained, box-section, cast iron bed, which is carried right down to the foundations. Heavy-section "horns" on this bench act as an abutment for the cast steel plug stop saddle. Plug rods are anchored to this saddle by a heavy forged steel yoke, which is provided with means of longitudinal adjustment through a handwheel-operated worm and wormwheel and screwed nut.

A large indicator dial is provided for recording the longitudinal setting of the plug rod. The saddle slides on accurately machined guide ways with suitable keep plates and is actuated to advance or retract the plug rod by twin pneumatic cylinders which have a 48in stroke. In the centre of the bed are five diabolo-shaped rollers which are not required when plug drawing. When mandrel drawing, however, the plug stop saddle is disconnected and removed, and these rollers simultaneously elevated by

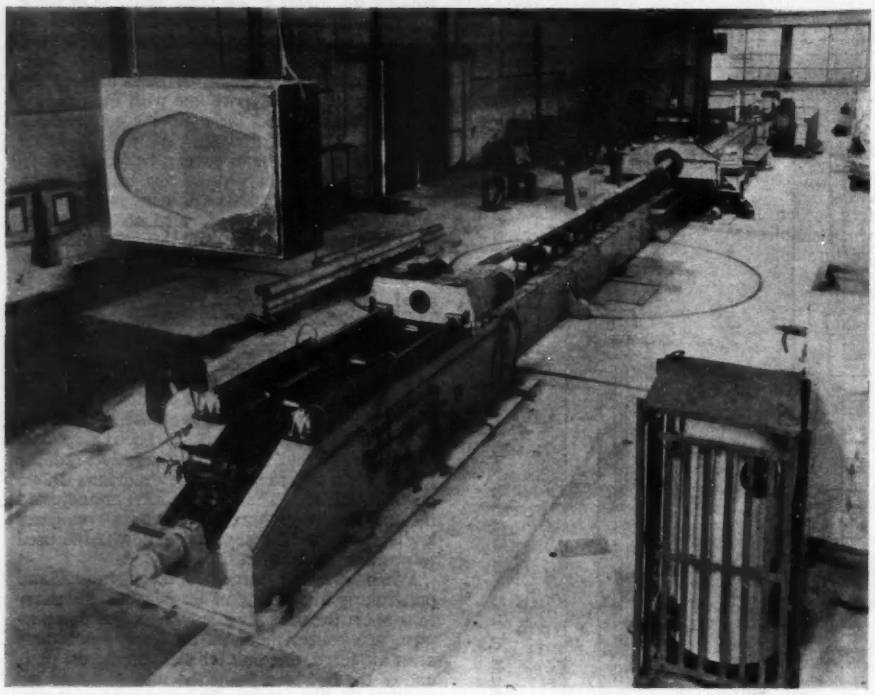


Fig. 3—150-ton drawbench for 17in diameter aluminium alloy tubes

means of a 1 h.p. motor to the correct mandrel bar setting height. These shaped rollers are, as are those on the turntable, mounted on ball and roller bearings for free rotation, and the thrust of the vertical adjusting screws is taken on ball thrust bearings.

A lubricating pump driven by a 2½ h.p. motor provides for internal and external lubrication of the tube during drawing. External lubrication is by an annular tubular spray mounted on the die plate holder. For internal lubrication an underground pipe is taken from the pump to the plug rod bench, where it is connected by a flexible hose to the hollow plug rods.

The operation of the machine when mandrel drawing can be followed with reference to the upper elevation of the drawing, Fig. 2. It is as follows : after the turntable and plug bench support rollers have been set to the correct height the tube to be drawn is dropped on to the turntable rollers and the mandrel bar is dropped on to the plug bench rollers as shown. With the tube stripper plate on the drawing centre to prevent end movement of the tube, a pull-through bar is pushed through the tube and attached to the leading end of the mandrel bar and also to the draw carriage, which is close to the die plate. The draw carriage hook is engaged with the main chain and the draw carriage then traversed up the bed, so pulling the mandrel bar into the tube to be drawn. The pull-through is discarded, the tube stripper plate slid to one side, the die plate slid into drawing position, and the draw carriage returned down the bench to grip the mandrel end. Drawing proper then commences and the tube and mandrel bar are drawn completely through the die, whereupon the die plate is slid to one side. An adapter on the end of a wire rope cable is then attached to the back end of the mandrel bar and the wire rope cable hauled in by a winch mounted at the extreme back end of the machine. This drags the mandrel with the drawn tube on to the support rollers of the turntable, which is then rotated through 180 deg. The back end of the mandrel is then pushed through the hole in the stripper plate, which has been moved on to the drawing centre. The draw carriage is engaged with the mandrel end and, after hooking in, draws the mandrel from the tube, which is left on the support rollers on the turntable. After removal of the finished tube, the mandrel is returned down the bench on to the support rollers of the back bench ready for the next tube.

For plug drawing, the arrangement is generally as shown in the lower view of Fig. 2. A suitable plug rod is connected to the plug stop saddle and supported on the rollers of the turntable with the plug stop saddle in the retracted position. The tube to be drawn is lowered on to the machine at the chain side, and it is supported at one end in an adapter attached to the drawing carriage and at the other end by the pneumatically operated retractable support rollers adjacent to the die plate end of the bed. Without the die plate in position, the draw carriage return traverse is operated and the tube is pushed over the plug and its rod. The die plate is then moved across into the drawing position. The pneumatically operated plug stop saddle with the plug rod attached is traversed forward, so pushing the end of the tube with the dolly (which has previously been inserted), through the die so that the end of the dolly can be gripped by the jaws of the draw carriage. The hook is engaged in the chain and the draw carried out leaving the finished drawn tube supported over the main bed from where it is removed by the overhead crane after the dolly end has been removed. The plug is then retracted and the die plate slid to one side ready for the cycle to be repeated.

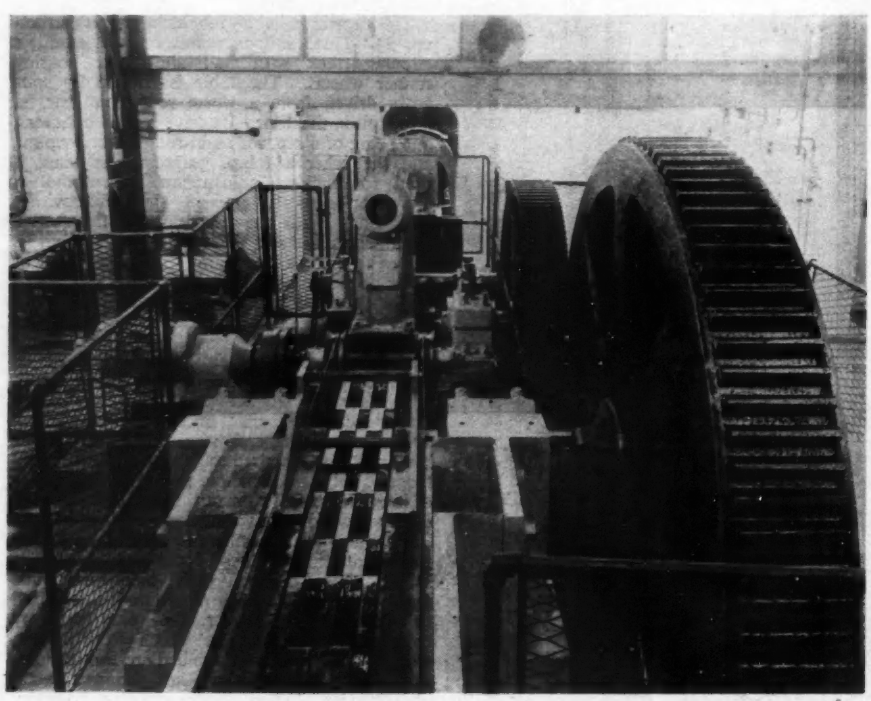


Fig. 4—Main drive of drawbench in which a 150 h.p. motor drives the final 10ft 6in gear through a magnetic coupling, a two-speed gear, worm reduction and spur reduction gearing

Scottish Industries Exhibition

THE Scottish Industries Exhibition was opened at Kelvin Hall, Glasgow, on Thursday of last week by Queen Elizabeth, the Queen Mother. This exhibition shows the steady expansion of the manufacturing industries which has taken place in Scotland in the five years which have elapsed since the last exhibition was held in 1949. Of the 220 firms represented, more than a third are concerned with the engineering and allied industries, whilst the remainder make a variety of consumer goods and other products including textiles, furniture, plastics, chemicals, domestic equipment, &c.

The products of many of the engineering firms exhibiting will be well known to readers of THE ENGINEER. Despite this fact, the professional visitor will find that the exhibition provides an interesting general survey of the many engineering products now manufactured in Scotland. Those stands of engineering interest are conveniently grouped and well arranged mainly with smaller items of representative equipment, together with models, photographs, &c., of larger equipment.

One of the largest stands is that occupied by the North British Locomotive Company, Ltd., of Glasgow, which, in addition to one of its 100 h.p. "Miner" locomotives, is showing a model and diagrams of the experimental coal-burning gas turbine locomotive it is building in conjunction with C. A. Parsons and Co., Ltd., to the order of the Ministry of Fuel and Power. This locomotive will be of 1750 h.p. and is designed to develop a starting tractive effort of 45,000 lb when used for freight train haulage, in which service its maximum speed will be 50 m.p.h. When used for passenger train working it will have a maximum speed of 72 m.p.h. and a starting tractive effort of 30,000 lb.

The locomotive will work on the exhaust heater principle and have an exhaust heater which resembles a fire-tube boiler, except that it

heats air instead of water. Air is drawn in from the atmosphere and delivered under pressure round the tubes of the boiler, where it is heated to nearly 1300 deg. Fah. The hot compressed air is first used to drive the turbine which provides the power for the compressor, and the surplus power is used to drive a second turbine geared to the locomotive wheels. The air passes on to the combustion chamber, where pulverised coal is blown in.

The air and burnt gases are well mixed to prevent hot spots and pass through the flue tubes of the boiler to heat the incoming cold air on its way from the compressor to the turbines. The air and burnt gas on its way to exhaust is used to raise steam in a boiler for heating passenger trains. It will be appreciated that the advantage of this system is that the compressor and turbines run in clean air and are not subject to wear or corrosion from ash or combustion products.

In addition to examples of the condensers, turbines and pumps, which it makes, the Mirrlees Watson Company, Ltd., Glasgow, is showing an interesting model of a typical modern sugar mill. This model demonstrates graphically the space saving which is effected by introducing a steam turbine for the drive, and the many developments which have made possible increased output with much reduced maintenance in an up-to-date sugar mill.

The products of the group of companies controlled by G. and J. Weir, Ltd., are shown on a large composite stand. By the use of diagrams and models, the parent firm illustrates the equipment it makes for boiler feed pumping and feed heating auxiliaries for many applications.

A working boiler unit on the stand taken by Cockburns, Ltd., Cardonald, Glasgow, incorporates a relay operated safety valve, an automatic feed regulator and a soot blower. Shown in conjunction with this is an assembly designed to demonstrate the operation of the firm's self-closing and emergency stop valve, with its associated governor and oil controls as supplied for marine steam turbine service.

Another exhibit is a combined main steam control unit incorporating an ahead turbine regulating valve, an astern turbine regulating valve, an astern turbine guarding valve, a turbine emergency valve, and a strainer. This is an actual unit as supplied by the firm for tanker service operating at 900 lb per square inch and 900 deg. Fah.

The principal exhibit of Babcock and Wilcox, Ltd., is a type "E" 64in coal pulverising mill, which is fitted with transparent plastic windows and driven at slow speed to show its operation. A large diorama depicts the wide field of industrial installations for which the firm supplies equipment, and includes power stations, gasworks, oil refineries, chemical plants, paper mills and shipping.

The Metropolitan Vickers Electrical Company, Ltd., is exhibiting some typical products of its factories at Germiston and Motherwell. These products include air coolers for large a.c. generators, oil coolers and switchgear. A coil winding machine for bi-metal strip, as used in "Sunvic" control equipment, is shown in operation, together with a number of typical instruments, relays, &c. One piece of new equipment on this stand is a "Raymax 60" X-ray diffraction unit of simple compact design.

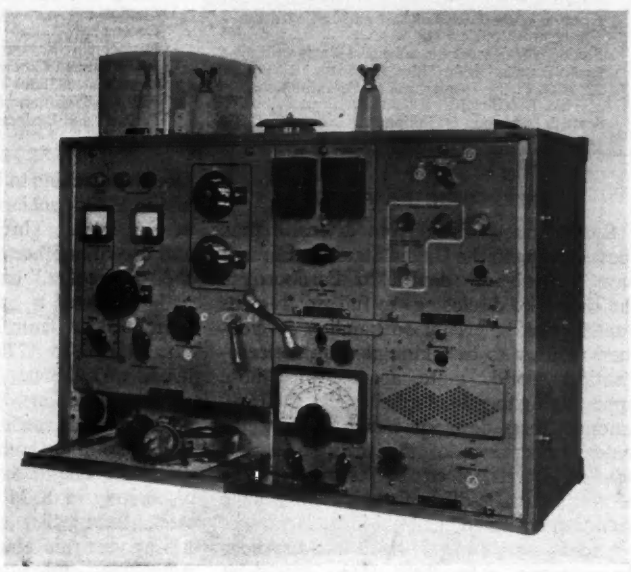
This apparatus comprises a continuously evacuated X-ray tube mounted above a high-vacuum pumping plant and connected by a high-voltage cable to a separate X-ray transformer. All electrical regulators and switchgear are assembled conveniently in a separate housing with a vertical control panel. The X-ray tube has rubber-sealed "O" ring joints, which are quickly and easily made. The cathode assembly has a negatively biased focusing shield, which, in conjunction with conveniently fitting filaments, ensures a sharp focus of 10mm by 1mm (or less) on the tube target. Although the high-vacuum pumping plant is not automatic and each sequence is initiated manually, a protective relay and electrical interlocks protect the equipment. A vacuum valve can be provided to shut off the diffusion pump if the target is being changed frequently, and stabilisers for both filament and high-voltage supplies can be built into suitable space provided in the vertical control assembly.

In addition to a model of one of its typical derrick cranes, the Anderson-Grice Company, Ltd., Carnoustie, is showing a selection of its diamond impregnated saws and other tools for stone and marble cutting and dressing purposes. A motor-driven saw bench on the stand is used to demonstrate the speed and efficiency with which these saws cut marble slabs.

Amongst the forgings, pressings and other products made by Barr, Thomson and Co., Ltd., there is shown a steel tank manhole door which has a special hinge arrangement which enables the door to be drawn out of the aperture and swung completely clear to leave an unobstructed opening. This door is supported from its centre column by an arm hinged on the support ring. The clamping cross bar is carried on the screwed central column and is locked by means of the usual hand wheel. To open the door the cross bar is unlocked and swung round parallel with the major axis of the oval door. The door is then pushed inwards, turned sideways on the hinge and swung round so that its minor axis is in line with the major axis of the opening. The door can then be pulled out of the hole and swung round quite clear of the opening.

The pumps for land and marine duties to be seen on the stand of Drysdale and Co., Ltd., Yoker, Glasgow, include the "Capsule" axial-flow pump, particularly intended for the circulation of transformer oil. This pump has the suction and discharge branches in line, and the motor, which is fitted to the pump cover, runs in the oil being pumped, the impeller being attached to an extension of the motor spindle. The advantage of this design is that by closing the suction and discharge valves the entire pump and motor unit can be removed without loss or drainage of oil.

An interesting model on the stand of Glenfield and Kennedy, Ltd., Kilmarnock, shows the arrangement of the drum gates supplied by the firm for the spillway at the Pitlochry hydro-electric station. There are also models and photographs of different classes of equipment made for the control of water in water and sewage works, irrigation projects, &c.



"Salvare" radio transmitting and receiving installation for motor-propelled lifeboats.

Radio Installation for Ships' Lifeboats

A NEW radio transmitter and receiver, designed for permanent installation in motor-propelled lifeboats, has been produced by The Marconi International Marine Communication Company, Ltd., Chelmsford, Essex. This equipment, which is known by the name "Salvare," has been type-approved by the Ministry of Transport and the General Post Office. It is a self-contained medium and short wave transmitting and receiving installation built into metal racking which is enclosed in a canvas-covered wooden cabinet.

When the "Salvare" equipment is opened up for operation, a sliding shelf below the transmitter is withdrawn as shown in our illustration. This shelf is a support for a message pad and it carries the simple instructions needed for operating the installation. The controls are numbered consecutively in the order in which they are to be manipulated, and an unskilled person can operate the "Salvare" simply by following these numbers in sequence. For instance, the figure 1, painted on the front panel, indicates the setting of the send/receive switch to the receiving position, the figure 2 indicates the switching-on of the power from the batteries, the figure 3 shows the switching of power through to the transmitter, and so on. A built-in meter facilitates rapid checking of battery voltage and transmitter valve feed current. Automatic keying is incorporated as well as a hand key for use by a skilled Morse operator or radio officer.

Both transmitter and receiver are powered by a 24V, 144A/h battery charged by a generator driven by the lifeboat's motor. The "Salvare" can thus be operated on the "floating battery" principle without diminishing the battery e.m.f. While the lifeboat is on board its parent ship the battery is, of course, charged periodically from ship's mains, which are also available for the operation of drying heaters incorporated in the "Salvare."

The transmitter is pre-tuned to a spot frequency of 500 kc/s on medium frequency and to 8364 kc/s on high frequency, power outputs being 50W and 60W, respectively. An L.C. master oscillator is used for medium frequency control, crystal control being employed for H.F. transmission. Automatic keying provides for either "Alarm" or "Distress" transmission, or for both when used on 500 kc/s. Setting the switch to the "Alarm" position actuates the mechanism for the transmission of the international auto-alarm signal of twelve four-second dashes, at the end of which the transmitter switches itself off. When set to "Distress" the "Salvare" will send S.O.S. three times, followed by a long dash of fifty-four seconds, and will continue to transmit the distress sequence at twelve-minute intervals until switched off. While it is kept in this condition the auto-sender "Ready" lamp lights at intervals of eighty-seven seconds throughout the non-transmitting periods to indicate that the set is still functioning.

The receiver of the "Salvare" is a compact eight-valve superheterodyne set which is housed in a chassis between the transmitter on the left and the transmitter h.t. on the right. The controls are simple and the receiver is tunable over the two frequency bands of 480–525kc/s and 8200–8800 kc/s. Both the receiver and the transmitter are fully "tropicalised."

The set can be used with either a mast-rigged aerial or an aerial suspended from a flown kite. Three independent aerial insulators are provided —one for medium frequency transmission via kite aerial; one for m.f. transmission using a rigged aerial; and one for high frequency transmission using either form of aerial. A fourth aerial insulator, placed away from the others, is for working into a dummy aerial load for testing purposes.

The overall dimensions of the "Salvare" set are: height 2ft 4in, width 2ft 10½in, depth 1ft 6in, and the weight is approximately 200 lb.

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SUPERSONIC RESEARCH

Security restrictions more extensive than those existing in the United States and France have undoubtedly denied to Farnborough the chance of disclosing the full worth of its contribution in several outstanding developments known to be taking place in the aeronautical world, quite apart from those appertaining to guided missiles. In the U.S., amongst these developments have been the sudden emergence of the truly supersonic combat aircraft, of combat aircraft capable of vertical take-off, of which two have been demonstrated, and the effectiveness of boundary layer control which has also been demonstrated. In these three categories there is no contestant at Farnborough, although a supersonic interceptor, which was only recently flown, was expected. It is therefore all the more astonishing to learn from American sources brief details of no less than seven types of supersonic aircraft of which at least the prototypes have flown. They belong to a group named the "F100" series and are regarded as being capable of sustained supersonic flight in combat having different maximum speeds in the bracket extending from Mach number 1·3 to 2·5. In most cases production has started or has been ordered. Behind this startling development which would seem to render inferior, if not obsolescent, aircraft of the "Sabre," "Hunter" and "Swift" categories, lies an outstanding Government-sponsored research programme. It goes back to 1945, was conceived when existing wind tunnel facilities in the United States were inadequate—as they were here also—and in spite of the hazards attendant upon such flights, this programme was pursued after the decision had been taken in this country to defer temporarily further piloted supersonic research. It is of interest to trace briefly that programme.

It was largely undertaken by the Bell and Douglas Aircraft Companies, using for the most part rocket-propelled aircraft launched in many cases from a parent aircraft. The first Douglas machine to fly was the "Skystreak," and in 1947 it achieved a speed of 650 m.p.h. at sea level. Three of them were made and one of another three modified machines, the "Skyrocket," having swept wings, eventually achieved a speed of 1238 m.p.h. in a shallow dive from 79,494ft, in 1951, a figure since raised to 1278 m.p.h. diving from a height of 83,235ft. Of the Bell "X" series of aircraft different advanced designs and constructional methods were similarly used. The use of unorthodox metals was evaluated, at least one aircraft being constructed extensively in K-Monel metal and stainless steel. Altogether seven were built, some having very thin straight wings, others were fully swept, and one, the "X5," was used to investigate the use of flight variable sweepback. The first flew in 1947 in piloted free flight, and in that year, using its rocket motors, exceeded Mach 1. A slightly modified stub wing version has more recently flown at Mach 2·5, which, at its probable flying height, is in the region of 1,700 m.p.h. It was the duty of another machine, made by Northrop, the "X4," to investigate the characteristics of tailless aircraft. The latest in the family of supersonic research aircraft to fly, the Douglas "X3," has been christened recently the "Flying Stiletto," so unusual is its configuration. A maximum speed in the region of Mach 3 is claimed for it, and it uses turbo-jet and possibly ram jet propulsion. Upon the lessons learned with these craft there have been based the designs of the "F100" series, with their various plan forms. The immediate production was made possible by the advent of turbo-jet engines giving up to 15,000 lb static thrust with after burning whose production is now extensive. Amongst these aircraft is the Convair "F-102," a Mach 2 delta interceptor, which is to mount the "Falcon" guided missile; the Douglas "Skyray," another delta aircraft for both Navy and Army use; and, using titanium in its structure, the "Super Sabre" ("F-100"), the first in the series which is already stated to have attained a speed of Mach 1·38. The Lockheed "F-104" is another Mach 2 machine with straight, thin stub wings and regarded as a light-weight "utility"! Another machine which is expected to fly very shortly is the delta wing "F-105," 90 per cent of which is made of titanium. It employs a 10,000 lb thrust turbo-jet engine with supplementary ram jet propulsion and the designed maximum speed is given as Mach 3. The machine is said to be developed from an earlier prototype having similar propulsion and variable incidence wings with inverse taper, which is claimed to have exceeded Mach 1 in level flight as early as 1952.

However accurately or optimistically this American programme has been reported and whatever troubles, trials and tribulations the Americans may in fact be experiencing, there can be no disguising the lavishness of expenditure in this field alone. Neither has the programme been accomplished without loss of life, and at least three of the Bell aircraft are known to have been destroyed. With different aircraft the supersonic flight development programme has embraced the evaluation of aircraft having wings with variable sweep or variable incidence in flight, the delta, the thin straight wing, the swept wing, and the tailless plan form. Nothing like it has been reported in this country and there can be little doubt that America has at this time a considerable lead in this field. It may be that, due to our deferred interest in this sphere, we are now able to draw upon sources of information and particularly upon wind tunnel research data with which much of the above flight development can be by-passed. Certainly there are now available large turbo-jet engines giving the necessary thrust at altitudes which were not available to the Americans in 1947. Furthermore, in view of the large number of American delta supersonic machines, the "know how" we have obtained from the subsonic delta aircraft which have been under intensive development here must be of immense value. It is even now reported that a small Avro supersonic delta has been developed and there is also the possibility that the latest twin jet aircraft being shown at Farnborough may themselves be developed as supersonic aircraft. There is thus a great possibility here. Nevertheless, it must be conceded that the American aircraft industry seems already to have rent the supersonic region wide open. It has set the pace and it has declared that the piloted supersonic guided missile carrier will remain the primary vehicle in its armament. Very recently it has announced that £30,000,000 a year is to be spent on the development and production of the Convair "Hustler" 1000 m.p.h., delta winged, piloted bomber. This country can never hope to challenge the production capacity of that industry, now the largest in the U.S., which employs 816,000 people and is producing jet aircraft at the rate of 9600 and jet engines at the rate of 40,000 per year. But if it is to survive at all it must at least seek to retain a parity in design. To do this it must make capital out of its native ingenuity, inventiveness and improvisation. The evidence at Farnborough this year that it is doing so in the military sphere was far from reassuring. But the secrecy that conceals British development is much more stringent than that covering American progress. Does it stifle

public knowledge about advances as startling and rapid as those being made across the Atlantic ? Or does it, reprehensively, conceal our failure, after leading the world in gas turbine development, to maintain a pace of aeronautical development which that lead should have given us ? The creation of such a doubt is one of the disadvantages of secrecy that the Services fail so often to comprehend. If we are spending too little upon development, who else but the public, led by its technical men can, in a democracy, bring sufficient pressure to bear to rectify the situation ?

THE NAVY'S MANPOWER PROBLEMS

In a recent issue we published in these columns an appraisal issued by the Admiralty of the estimated strength of the Russian Navy in 1957. It was an alarming picture and showed clearly the need, not only for an intensification of our anti-submarine and mine measures, but for no further delay in the commencement of a building programme of carriers and cruisers. In 1951 the Government made provision for the construction of 150 minesweepers capable of dealing with all kinds of mines and some seventy fast anti-submarine frigates, and we can now face the submarine and mine danger with some hope of being able to deal with it. But we have neglected the large ships, apart from hastening the completion of six carriers which were laid down during the war. Inevitably this concentration of effort on building small ships has led to a decreasing interest in the value of sea power and in the Royal Navy's offensive role. The nation indeed lacks any indication of what the broad purpose of the Navy is to-day, and there is little doubt that this accounts to a large extent for the Navy's manpower difficulties. For some years after the war recruiting for the Senior Service left little to be desired, but during the past eighteen months there has been a sharp fall in regular recruits for the seamen and stoker branches and for the Royal Marines. Moreover, as in the other two Fighting Services, the number of re-engagements for pension are still much below the normal and at the present time only a third of our regular ratings are over twenty-five years old. Much is hoped, however, from the recent increases in pay to selected officers and experienced ratings and from the reduced periods of foreign service now introduced. The officer situation is no less serious, the number of suitable entries at sixteen years of age—particularly for the Engineering Branch—being far short of requirements. In an effort to remedy matters Parliament has recently approved a new scheme under which all cadets enter at eighteen years of age. Further consideration is being given to the question of having one single entry of cadets with appointments to branches at a later stage. In the meantime successful candidates will continue to enter as executive, engineer or supply and secretariat cadets. They will receive an all-through course of training centred at Dartmouth, partly on shore and partly afloat in a small squadron of H.M. ships, the whole of this early training lasting two years. They will then go to sea with the fleet as acting sub-lieutenants to complete their training. To enable boys to continue their education at their present schools until eighteen, the Admiralty has instituted a scheme of scholarships to be competed at the age of sixteen. The new scheme has the merit of being free from any taint of party or class interest, but whether it will produce the numbers required is by no means certain, in view of the competition from the other Services and more especially from the universities.

Electrical Branch cadets will take part in the preliminary stages of the Dartmouth training before going on to do a university course and works training. The naval electrical branch is also at present short of suitable entries. Until 1946 this was a civilian branch in the Department of Electrical Engineering with responsibility for the design and maintenance of electrical equipment. Successful candidates now enter as naval officers, but those coming forward do not show promise of making good designers. According to Viscount Caldecote, who is closely associated with the education of naval electrical officers, the most suitable will not join the branch until it is clear what they are intended to become—naval officers who know a little about electricity or, first and foremost, electrical engineers for the design and upkeep of electrical equipment. No doubt the branch suffers from being comparatively new and from being insufficiently advertised in the schools most likely to provide suitable recruits. There is also the disadvantage common to all technical branches of the Royal Navy, that an ambitious, clever lad feels that there is no opportunity of getting to the top of the Service. There is no technical officer of any kind on the Board of Admiralty, which seems out of step with modern ideas. Nor is it practicable to give the command of a ship to an officer wholly concerned with equipment.

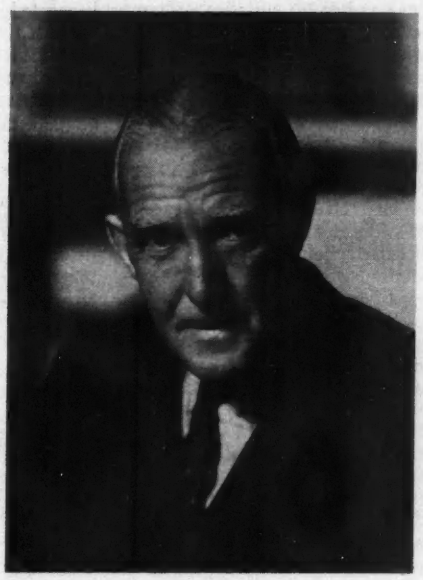
Another serious manpower problem is the shortage of naval constructors, who, unlike their colleagues in the United States Navy, are civilians and not naval officers. The position regarding the Royal Corps of Naval Constructors is indeed worse now than it ever was. The university entry introduced at the beginning of the war has not proved successful, almost all those who joined the Corps having since left. Other sources of entry, from the dockyards and elsewhere, have also largely dried up and the many attempts to improve recruitment have all failed. At present draughtsmen and design assistants are being promoted into the Corps to fill the gaps. The problem has not been fairly and squarely faced, the Royal Corps being equated with scientific civil servants. This is wrong in principle. Scientists produce the ideas ; engineers recruited to the Corps put those ideas into action and production. These are but a few examples of the many manpower problems facing the Navy at the present time. The basic cause for all these difficulties is, in our judgment, the lack of knowledge of what sort and size of Navy this country is to have and the emphasis which has been laid on the Navy's defensive function. The remedy is to build the kind of ships which will enable the Royal Navy to carry out its traditional role of furnishing mobile striking power overseas ; and to ensure that, even if the Royal Navy must be inferior to the U.S. Navy, it is superior in strength to all others.

Obituary

SIR JOHN KENNEDY, O.B.E.

ENGINEERS, particularly those concerned with the electricity supply industry, will have learned with regret that Sir John Kennedy, a former chairman of the Electricity Commissioners, died, at the age of seventy-four, at his home in Shalford, Surrey, on Tuesday, August 31st.

John Macfarlane Kennedy, son of the late Sir Alexander Kennedy, LL.D., F.R.S., was born in London on October 12, 1879, and was a pupil at University College School. On leaving school he studied for a year at Zurich Polytechnic before starting his practical training by serving as a pupil with Richard Moreland and Sons from 1896 to 1897. He then went up to Trinity College, Cambridge, where he took the Mechanical Science Tripos. Continuing his practical



Sir John Kennedy

training, he was indentured with the Rugby firm of Willans and Robinson from 1900 to 1901, when he went to Germany to spend a year with the firm of Siemens and Halske, in Berlin, where he interested himself particularly in electric traction.

In 1902 he started as an assistant with Kennedy and Jenkin, the firm of consulting engineers that is now known as Kennedy and Donkin. There, for the next twelve years, he was mainly concerned with a number of electric traction schemes, starting with the reconstruction of the London County Council tramways, on the conduit system, and with the Hammersmith and City Railway. He also worked on the conversion of the Edinburgh tramways from rope haulage to electric traction. Later he carried out preliminary design studies for electrification of the suburban lines of the London and North-Western Railway and the western section of what is now the Southern, but, although construction started before 1914, completion of these schemes had to be deferred until after the 1914–1918 war. From 1916 to 1918 he served as superintendent of the Government rolling mills at Southampton and for his wartime services he was made an O.B.E. in 1919.

On rejoining Messrs. Kennedy and Donkin after the war he became increasingly interested in the problems of electricity supply and he soon concluded that the shortcomings of the electricity supply industry were not

corrected by the post-war Electricity Acts. As a result of his studies in 1922 he submitted proposals to the Electricity Commissioners for the reorganisation of electricity supply in Great Britain and later he compiled a report on the same subject for the Ministry of Transport.

After the passage of the 1926 Electricity Act he collected, for the Electricity Commissioners, the technical and financial information which formed the basis for the regional electricity schemes of the Central Electricity Board ; for the next six years he was closely associated with his firm's work for the Board in the design and construction of many of the regions of the British grid. During this time Sir John also designed, on behalf of the Government of Northern Ireland, an electricity grid and distribution scheme for the whole of that country outside the city limits of Belfast and Londonderry. He devised a similar scheme for the Isle of Man, whereby supplies of power generated in Douglas and surplus to its requirements, would be purchased by an Electricity Board who would be responsible for distributing and selling electricity throughout the island.

In 1934 he was appointed an Electricity Commissioner—an office which enabled him to help in shaping the first part of the co-ordination of electricity supply. He was deputy chairman of the Electricity Commissioners from 1938 until 1947, when he became chairman for the last year of the Commissioners' existence. By then he had seen the first function of a co-ordinated electricity supply system—that of interconnected generation and transmission—established in Britain ; he had seen this integrated system of generation and transmission withstand the emergency demands of wartime, and he had had the satisfaction of knowing that those demands could not have been met but for the economy in generating plant that was the essence of the grid system. By then distribution was the only function that remained outside the orbit of the co-ordinated electricity supply system.

But the distribution of electricity had for long claimed a great deal of Sir John's attention, and this topic was prominent in his inaugural address as president of the Institution of Electrical Engineers in 1935. In this address, he emphasised the need to reduce the cost of electricity. He sought to show that any further reduction in operating costs due to co-ordination of generation must be small compared with those that had already been achieved ; for further progress one must look to the distribution side to effect the necessary economies. Sir John's optimism and confidence in the future of the electricity supply industry was clearly declared in the final portion of his address in 1935. There he forecast that long before 1960 " the industry should be able to account for more than 10,000,000 domestic consumers " ; this figure was, in fact, reached before " vesting day." He went on to suggest " 47,000 million units [of electricity] as a goal to be aimed at in the next ten to fifteen years at the outside." In the event the sales of electricity reached more than 46,500 million units in 1950–51. Sir John's goal might well have been achieved much earlier but for the fact that his hopes for extensive railway electrification were not realised.

After the nationalisation of the electricity supply industry, which was followed by the winding up of the Electricity Commissioners in 1948, Sir John accepted an invitation from the Uganda Electricity Board to become its London director. In this capacity he paid a number of visits to Uganda during the development of the Owen Falls hydro-electric scheme. Because of ill health he retired from the Board in 1952, but he lived to see the inauguration of the Owen Falls scheme, which was opened by Her Majesty the Queen earlier this year. On his retirement from the Board he accepted a post as consultant to Messrs. Kennedy and Donkin.

Sir John Kennedy was knighted in 1943. In recognition of his services to the electricity supply industry and to the Institution of Electrical Engineers, he was elected an honorary member of the Institution in 1947. He was also a past-president of the Association of Supervising Electrical Engineers and a member of the Institution of Civil Engineers.

A Memorial Service will be held at The Queen's Chapel of the Savoy, Savoy Street, W.C.2, at 12.15 p.m. on Thursday, September 16, 1954.

CAPTAIN F. W. SPENCER

We have learned with regret of the death of Captain Frank William Spencer, which occurred at Phillack, Hayle, Cornwall, on August 22nd, after a long illness. Captain Spencer was born at Coventry and received his general education at King Henry VIII Grammar School in that city. He served an apprenticeship with Brett's Patent Lifter Company, Ltd., Coventry, and subsequently held positions in the works of J. Hands and Co., Ltd., Birmingham ; Nelsons, Ltd., Stockton-on-Tees, and Edgar Allen and Co., Ltd., Sheffield, where he was in charge of the erection of cement manufacturing plant.

In 1911, Captain Spencer went to the U.S.A. as an engineer-demonstrator for the Sturtevant Company, but he returned to this country upon the outbreak of the first world war, throughout which he served overseas in the South Midland Royal Field Artillery. After the war, Captain Spencer joined the staff of the B.S.A. group, on whose behalf he spent some years in Germany and the U.S.A. Upon his return to this country he was for a time production manager of Holman Brothers, Ltd., Camborne, and later works manager for Thomas Smith and Sons, of Saltley, Ltd. In recent years, Captain Spencer had lived in Cornwall, and had served successively as honorary secretary and president of the Cornwall branch of the Institution of Production Engineers. He was a member of the Institution of Mechanical Engineers, and, over a long period, was also actively concerned with the work of the Association of Drop Forgers and Stampers.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

" YE SHALL BE AS GODS, KNOWING GOOD AND EVIL "

Sir,—You ask : " Who are engineers that they should take decisions as to what they should or should not make ? "

Who are they, indeed, if not responsible men with informed and lively consciences and who will think twice and act wisely ? Surely any and every man has the right, and duty, to obey his conscience. In this matter of the choice between good and evil, why should engineers be the slaves of communities and governments ? We have lost a great deal of subsidiary function since governments took to themselves what should reasonably be done by local, regional and professional organisations. Would you have a completely servile State ?

You speak as though the lives saved by radio-active isotopes excuse the lives lost in Hiroshima and Nagasaki, and as though modern civilian air traffic excuses obliteration bombing from aircraft. If this is so, I consider your reasoning on " means and ends " is ill-founded.

The use of the word " merely " in its context in your first editorial for August 20th, and the trend of your argument, convinces at least one reader that you have missed the point of the doctrine of original sin and that your views on moral philosophy are confused and obscure.

Stick to technology—you do all right at that.

L. P. Barker, M.I.Mar.E.

Altrincham, August 29th.

[We indignantly deny the imputation of our correspondent's third paragraph. We wrote : " Knowledge is neither good nor evil ; but it is power. If it can be applied for evil and destructive ends it can also be applied constructively." It was in that context that we referred to air warfare and civil airlines, to atom bombing and radio-active isotopes. Whether one " excuses " the other was not discussed, and in our view is not a question for discussion in this journal. We prefer to stick to technology !—Ed. The E.]

Sir,—It is agreed that happiness, however we define it, is not a result of " the possession of all those material things that scientific discovery and engineering invention has brought," but what is overlooked is that engineering does not, as is usually assumed, bring abundance and relief from poverty. Friedrich Juenger says : " What is euphemistically called production is really consumption. The gigantic technical apparatus, that masterpiece of human ingenuity, could not reach perfection if technological thought were to be contained within an economic scheme, if the destructive power of technical progress were to be arrested. . . . Its (technology's) concomitant is waste and contempt for all rationality in the exploitation of the sources on whose existence technology depends, as the lungs depend on air. . . . The machine invades the landscape with destruction and transformation ; it grows factories and whole manufacturing cities overnight, cities grotesquely hideous, where human misery is glaringly revealed ; cities which, like Manchester, represent an entire stage of technology and which have become synonymous with hopeless dreariness. Technology darkens the air with smoke, poisons the water, destroys the plants and animals. It brings about a state in which nature has to be " preserved " from rationalised thinking, in which large tracts of land have to be set apart, fenced off, and placed under a taboo, like museum pieces. What all museum-like institutions make evident is that preservation is needed."

" Human pauperisation begins with the proletarianisation of the masses, who are indoctrinated to factory work. . . . . The exploitation of the factory worker is an inevitable symptom of the universal exploitation to which technology subjects the whole earth. . . ."

It is true that the engineer rather than the scientist has created the modern world, for had not the application of science to industry taken place science would be now what it was before, " the amusing hobby of charming old fools." It is also true that the engineer is not to blame for the decisions that have brought us to the present pass : they have to live, and to live they must sell their brain children. It is sad, though, that so few of us, through narrow specialisation, are unable to see the wider issues involved, are unable to ask where this so-called progress is leading us and whether the products we help to produce are really good, i.e. holy.

Since Butler wrote " Erewhon " and Morris prophetically thundered, the case against technology has been put with increasing force. Writers like Renè Guéron in his " Reign of Quantity " and Friedrich Juenger in his " Failure of Technology " have ruthlessly exposed the fallacies underlying technological thought.

The evil to be laid at the door of technology is

a spiritual evil, " the reduction of human beings to a subhuman condition of intellectual irresponsibility." It is what is done to the man on the belt, the precision worker, the victims of time and motion study, the man on the capstan, that is so distressing, but in passing, how much dissatisfaction is rife in the design office and drawing office, for the man who designs what he never makes also fails to fulfil his nature.

Thus, truly technology is a bed of Procrustes.

" SYSYPHUS."

Birmingham,
August 25th.

EULER'S CENTRIFUGAL PUMP THEORY

SIR,—In your issue of May 29, 1953, there was a short article by D. B. Welbourn on Euler's centrifugal pump theory. The expression for impeller head given as equation (4) in that article does not take impeller axial length into account and should therefore read

$$H_{impeller}=\frac{1}{g}\left[u_2^2-\frac{Qu_2}{2\pi r_2 l_2 \tan\beta_2}\right] \quad . \quad . \quad (4)$$

where l_2 is the axial length of the impeller at radius r_2.

The flow for which casing and impeller are perfectly matched is thus changed to

$$\frac{k}{r_2}Q=u_2-\frac{Q}{2\pi r_2 l_2 \tan\beta_2}$$

from which is obtained the modified equation (5)

$$Q=u_2\left[\frac{r_2}{k+\dfrac{1}{2\pi l_2 \tan\beta_2}}\right] \quad . \quad . \quad . \quad . \quad (5)$$

The expression for head lost in equation (6) of the note is in error, since the expression for the impeller velocity head should read

$$\frac{1}{2g}\left[u_2-\frac{Q}{2\pi r_2 l_2 \tan\beta_2}\right]^2$$

not

$$\frac{1}{2g}\left[u_2-\frac{Qu_2}{2\pi r_2 \tan\beta_2}\right]^2$$

Hence equation (6) becomes

$$\text{Head lost}=\pm\frac{1}{2g}\left[u_2-\frac{Q}{2\pi r_2 l_2 \tan\beta_2}\right]^2 \mp\frac{1}{2g}\left[\frac{k}{r_2}Q\right]^2 \quad . \quad . \quad . \quad . \quad (6)$$

As a result of these modifications the final equation derived in the original note should read

$$H_{pump}=\frac{1}{g}\left[u_2^2-\frac{Qu_2}{2\pi r_2 l_2 \tan\beta_2}\right]-\frac{1}{2g}\left[\pm\left(u_2-\frac{Q}{2\pi r_2 l_2 \tan\beta_2}\right)^2 \mp\left(\frac{k}{r_2}Q\right)^2\right] \quad . \quad . \quad . \quad . \quad . \quad (7)$$

A. D. MILLETT

Virginia Water, Surrey, June 24th.

[Mr. Welbourn comments that it is usual to write the expression in equation (4) for a unit impeller axial length and that to his mind the addition of l_2 only serves to make the expression less comprehensible. The intrusion of u_2 in equation (6) was an error.—ED., THE E.]

Books Received

Strength of Materials. Eleventh Edition. By A. Morley. London : Longmans Green and Co., Ltd., 6 and 7, Clifford Street, W.1. Price 21s.

Telecommunications. By A. T. Starr. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 35s.

Electric Power Transmission. By J. Zaborszky and J. W. Rittenhouse. New York: The Ronald Press Company, 15, East Twenty-Sixth Street, 10, N.Y. Price 12 dollars 50 cents.

Optical Instrumentation. Edited by G. S. Monk and W. H. McCorkle. London : McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 30s.

Tables of Integral Transforms. Volume I, Based, in Part, on Notes Left by Harry Bateman. London : McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 60s.

S.B.A.C. Flying Display and Static Exhibition

No. I

THE air display and static exhibition organised by the Society of British Aircraft Constructors is once again being held at the Royal Aircraft Establishment, Farnborough. There are 292 exhibitors, which is the highest so far, and a greater number of aircraft are being demonstrated.

In the static exhibition there could be discerned a few of the developments which are taking place in the design, construction and control of military aircraft. In at least three other spheres of development, however, upon which world aviation interest is now focused, British contributions have been masked by security. In the truly supersonic aircraft category the English Electric " P 1 " was not allowed to appear. The integration made possible by the gas turbine of lift and thrust, of which there are many exciting applications under development, has no place at Farnborough whatsoever. Mention was made, however, on Tuesday of a development undertaken by Rolls-Royce, Ltd., concerning the lift and propulsion of a device by jet thrust alone.

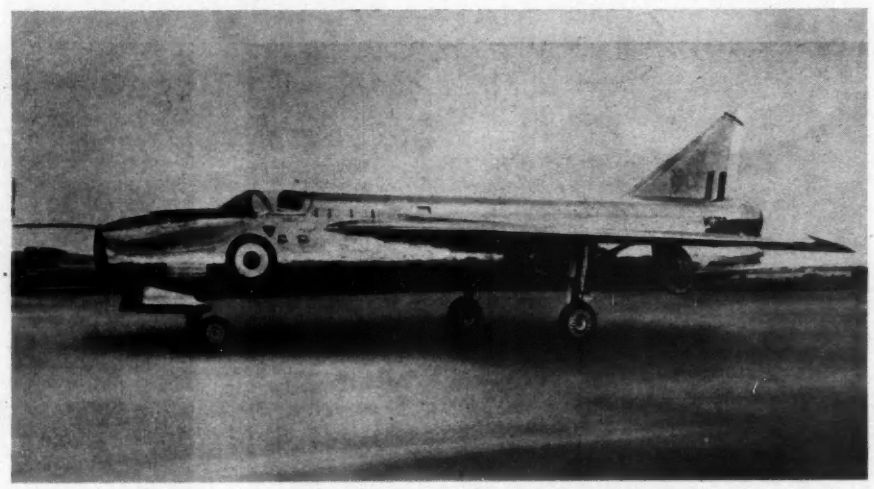
There is convincing evidence that this country maintains its lead in gas turbine technology, and one of the outstanding demonstrations is the flight of a " Meteor " powered solely by two small " Soar " engines, another development by Rolls-Royce, Ltd. These units, which form their own nacelle, are only 15·8in diameter and 62·75in long, yet each develops 1810 lb thrust for a weight of 267 lb. This performance is achieved without any concession to life or fuel consumption and represents one of the greatest achievements in this field.

We confine our remarks to military aircraft in this part ; one of the few new aircraft is the Folland " Midge," shown on page 365. The Folland " Midge," which can be described either as the prototype, or as the precursor, of the Folland " Gnat " light jet fighter, owes its existence to the discontinuation of the engine around which the " Gnat " was to have been designed. Folland Aircraft, Ltd., decided to build a prototype powered by an engine which was already in production and which had, in some degree, the special characteristics required for a light fighter project, although it had an output of less than one-third that of the " Gnat's " original engine.

Work on the design of the " Midge " began in 1952 and in well under three years the prototype had been designed, built and test flown. The first flight took place on August 11, 1954, at the Aeroplane and Armament Experimental Establishment, Boscombe Down, near Amesbury, Wiltshire.

No untoward incident has marked the progress of the flight trials. By the end of August the " Midge " had flown some sixteen hours and made more than thirty take-offs and landings. On no occasion was it unserviceable when scheduled to fly, nor was the start of any scheduled flight delayed.

In level flight the " Midge " has a top speed in excess of 600 m.p.h. despite the fact that its engine gives only 1640 lb of thrust. In a dive it has reached a speed corresponding to a Mach number of more than 0·9. It has a viceless stall, and can be kept straight by either rudder or control column during the approach to a stall. There is, too, ample stall warning.



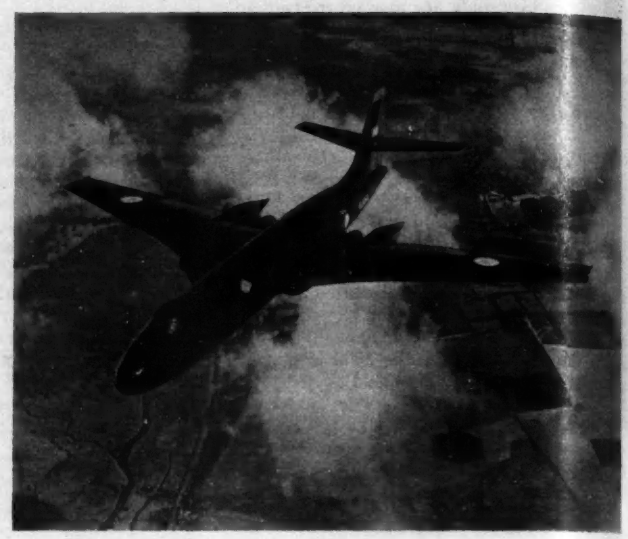
The English Electric " P 1 " supersonic interceptor fighter powered by two " Sapphire " turbo-jet engines

Some of its flying qualities can be attributed to its flying tail plane. In the Folland system the elevator acts as a servo and brings about changes in the setting of the tail plane appropriate to the prevailing condition of flight. Movement of the tail plane is by hydraulic power ; any "stick" forces left can be trimmed out by an electric motor which forms part of the tail plane power unit and is worked by a button on the pilot's control column.

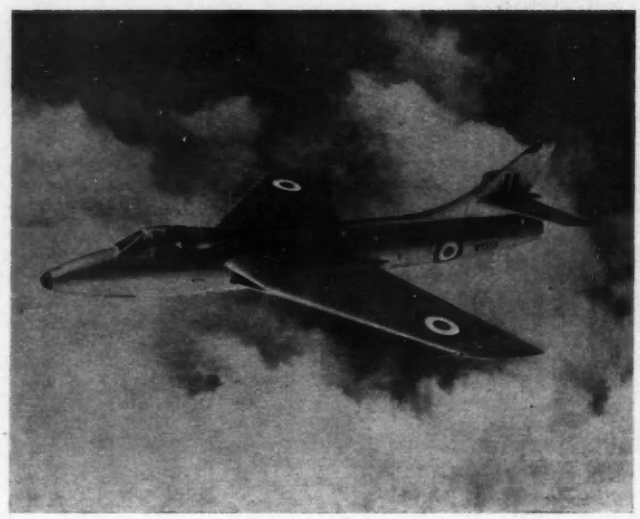
The " Gnat's " ailerons will be power operated and will give an exceptionally high rate of roll over a wide range of speed and height. The ailerons of the " Midge " are operated manually.

The wing is built in one piece and attached to the fuselage by bolts at four main points, a system that makes for quick and easy dismantling and reassembly, and wing changing. Being small, the wing could be given the strength and stiffness needed for supersonic flight without resort to complex structures

SOME MILITARY AIRCRAFT AT FARNBOROUGH

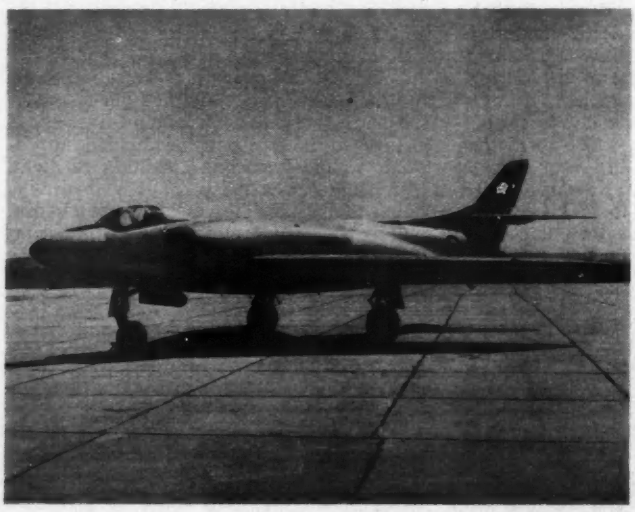


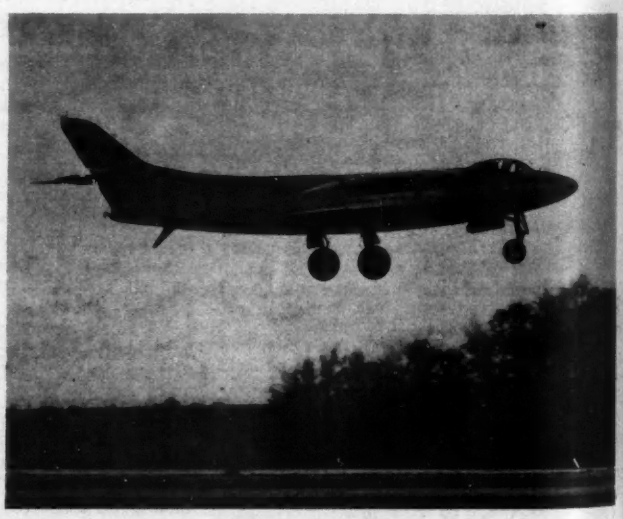
The Vickers "Swift IV" and the modified "Valiant II" with longer nose and nacelles for the bogie undercarriage



Hawker "Hunter" fighter

De Havilland "110" naval radar fighter





Vickers experimental swept wing naval aircraft

The English Electric "Canberra Mark B.2" night intruder

or heavy gauge metal. Equipment is reduced to essential items, and so placed that those needing routine attention can be reached without trestles or staging.

The "Midge's" leading particulars are: span, 20ft 8in; length 28ft 9in; height, 8ft 9in; sweepback, 40 deg.; aspect ratio, 3·3; undercarriage track, 5ft 1in. The "Midge" and the "Gnat" are "private ventures," sponsored and financed by Folland Aircraft, Ltd.

Visitors to Farnborough in 1951 will recall the demonstration of a single-seat, twin jet experimental naval fighter, the "Supermarine 508," made by Vickers-Armstrongs, Ltd. It had a low aspect ratio, thin, straight wing with an unusual tail configuration known as a "butterfly" tail. This arrangement dispenses with a conventional fin and rudder by having its tail planes set with 45 deg. dihedral and mounted from the end cone, which is hinged, of the fuselage. This aircraft which first flew in 1951, represented the first stage in the development of a twin jet carrier-borne, naval fighter.

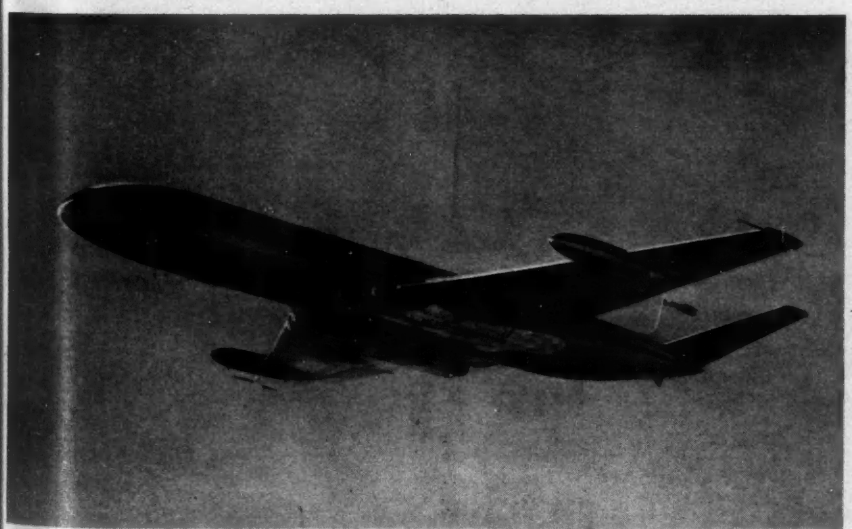
It has since been extensively modified and representing the second stage in this development here this year is the "Supermarine 525," which first flew in May this year. The aircraft has now a completely swept plan form and the "butterfly" tail replaced by a conventional swept tail and fin. Its engines remain Rolls-Royce "Avon" engines.

The Folland "Midge," prototype of the "Gnat" light jet fighter

Although this is not expected to be its final form, a considerable number of aircraft based on this version have been ordered. In spite of its thrust it has not been claimed as capable of level flight supersonic speed. No other details of this machine are available. The original version had a wing area of 340 square feet, was 50ft long and stood 11ft 7in high.

Another modified aircraft under development for the Royal Navy reappearing at Farnborough is the de Havilland "D.H.110." This is a two-seat radar interceptor in the same power and armament category as the "Javelin." Its two "Avon" engines, as with the "525," are of undisclosed thrust, the mounting of which is apparent from our illustrations of these machines. It was first demonstrated here in 1952 and exceeded Mach number 1 in dives that year. Since its disintegration during the air display in 1952 it has been fitted with an all-moving tail plane as distinct to the more usual variable incidence tail plane with elevators, and which is now generally regarded as essential in a supersonic aircraft.

In spite of its present thrust the makers state that the airframe is designed to make use of even greater power when this is available. With the thrust from two "Avon" engines these single and two-seat aircraft demonstrate exceptional rates of sustained climb. The "110" has a span of 51ft and is 52ft long. It first exceeded Mach number 1 in dives in 1952.



De Havilland "Comet III" with "Avon" turbo-jet engines

The most outstanding demonstration this year was again provided by the delta aircraft of the Hawker Siddeley Group. The occasion is the fly past in formation of six "Javelin" two-seat radar interceptors which are generally regarded as having guided missiles amongst their armament. Unlike the delta bombers, the "Javelin" mounts a high, adjustable delta tail plane at the top of the fin. The machine has two Armstrong Siddeley "Sapphire" engines of 7200 lb static thrust, mounted in nacelles merging with the fuselage. It first flew in November, 1951, and was one of the machines granted super priority production the following year. It is not claimed to be supersonic on level flight but, as with the "D.H.110," it has been exceeding Mach number 1 in the course of normal development flying. One of the development modifications is the cranked wing effect, seen on the fourth prototype. It results from the increased chord given to the outer wing panel so reducing the outboard sweepback.

One aircraft which since the "Beaufighter" has been responsible for night interceptions is the Armstrong Whitworth "Meteor" N.F.11. It is a modified Gloster "Meteor" which first flew in May, 1950, and there are

The Fairey "Gannet" anti-submarine aircraft

now four marks in squadron service. All of them retain the Rolls-Royce "Derwent" engine of 4000 lb static thrust, but all are distinguishable from the "Meteor" principally by the much extended nose which contains the radar equipment. In the latest variant at Farnborough is the "NF14," which has a fuselage longer than the "Meteor" and incorporates a very clear view, two-piece, sliding hood in place of the usual hinged cockpit. All the previous marks have mounted four cannons in pairs from the wings but there is no external evidence of cannon armament in the "NF14."

Sharing the night fighter role in the Royal Air Force are the de Havilland "Venom" II and III aircraft, which each mount a single "Ghost 504" turbo-jet engine of over 5000 lb static thrust. The Mark III version, which is displayed in the static park, has been further modified to incorporate the latest combat radar aids and improved controls. It is capable of a higher Mach number than the Mark II but is stated to retain the high altitude performance and manœuvrability for which the type is noted. The machine adopts side by side seating for pilot and radar operator. The Royal Navy is using a modified version of the Mark II aircraft which has power folding wings, catapult and arrester gear.

To accommodate the crew and radar gear the night fighter versions have a longer and larger fuselage than the fighter bomber version from which they were developed. The "Venom F.B. IV," the latest in this category, is also displayed in the static park. The "Venom" first flew in 1949 and the series has a straight, tapered thin wing with a low tail unit carried by twin booms.

Modifications largely affecting their combat and manœuvrability characteristics have delayed the entry of both the "Hunter" and the "Swift" single-seat fighters into full service use. The Vickers "Swift IV" commenced squadron service early this year, however, but was grounded following an accident to a machine which has involved modifications to the powered elevator controls. The standard power unit of this aircraft is a Rolls-Royce "Avon" engine with reheat, and it has the new standard main fighter armament of four 30mm "Aden" cannons. It is equipped with a pressurised cockpit, a refrigeration unit and the fully automatic Martin Baker ejector seat. A pressure refuelling system, the first fighter application, is incorporated and the company maintain that it has a greater internal fuel capacity and longer range than any contemporary aircraft in its class. This variant of the machine achieved a speed of 735·7 m.p.h. over the Libyan desert last year.

Final modifications to the Hawker "Hunter" fighter, which it is believed concerned the dive brakes, have now been completed and it is expected to enter squadron service later this year. The experimental prototype first flew in 1948 and in July, 1951, the Mark I version, which has the "Avon" turbo-jet with reheat, made its maiden flight. The Mark II with the "Sapphire" engine first flew sixteen months later. It has recently been announced that orders from fourteen air forces excluding the Royal Air Force for this aircraft now total £121 million. It is in production at the Kingston, Surrey, and Blackpool factories of the Hawker Aircraft Company, Ltd. The largest order was placed by the U.S. Government for N.A.T.O. and represented a little more than £60,000,000. Of the Dutch and Belgian orders (over £40,000,000) subcontracting of the machine under licence has been agreed.

Bombers

A demonstration is provided by Vickers Armstrongs, Ltd., of the Mark II version of the "Valiant" aircraft. Both the Mark I and the Mark II aircraft have four "Avon" turbo-jet engines enclosed within the wing roots which correspondingly have a large root chord. The wing is swept and tapered and has a sweep greater at the inboard section than at the outer wing, giving to the wing a cranked characteristic, as was noted on the Vickers "Swift" aircraft, and the "Javelin." One of the advantages derived from reducing the sweep on the outboard wing sections is that of reducing the tendency of the tip to stall at high angles of incidence.

The "Valiant II" first flew last September and although it flew over this airfield during last year's display it did not land. This version has a longer nose and each single tandem wheel arrangement on each leg has been replaced by a four-wheel bogie, the housing fairing for each of which can be seen protruding aft of the trailing edge. The "Valiant" first flew in 1952 and its delivery to the R.A.F. has already commenced.

The Avro "Vulcan" delta bomber is again in the flying circus. This machine is designed to mount the Bristol "Olympus" compound axial turbo-jet engine which was type tested at 9600 lb static thrust and has a performance at altitude unequalled by any American engine. The prototype displayed, however, is fitted with four "Sapphire" engines. Development of this aircraft is stated to be progressing very favourably. The "Olympus" powered prototype was damaged recently when forced to turn off the runway following the failure of its braking parachute. The "Vulcan," which has neither flaps nor tail planes, lands at speeds no higher than that of contemporary civil airliners.

(*To be continued*)

Tennessee Paper and Pulp Mills

No. II—(*Concluded from page 333, September 3rd*)

The official opening will take place on October 9, 1954, of the Tennessee Mills of Bowaters Southern Paper Corporation. Constructed in two years at a cost of 60,000,000 dollars, the mills are designed to produce 130,000 tons of newsprint and 55,000 tons of kraft pulp annually, which makes them the largest of the three newsprint mills in the southern United States. The entire newsprint production has already been purchased for the next fifteen years by over a hundred publishers in the southern states, while the output of pulp will be exported to the United Kingdom for use in the manufacture of newsprint and of printing and packaging papers.

Feed-water System.—Make-up water is added to the condensate storage tank together with the mill and condenser hot well returns. This make-up varies between 20 and 50 per cent of the total feed-water flow, depending on the operating conditions.

A condensate pump (with a standby pump) takes water from the condensate tank and pumps it to the deaerating heater, which operates at 5 lb per square inch gauge and reduces the oxygen content to 0·005 c.c./litre.

Water at approximately 228 deg. Fah. leaves the deaerating heater and falls to the boiler feed pumps. The feed-water pump raises the water pressure to approximately 1080 lb per square inch which is sufficient to carry the water through the closed No. 2 heater through the feed-water control valves and into the boilers. This heater receives steam from the 50 lb per square inch gauge header in order to heat the feed-water to 280 deg. Fah. Its condensate is discharged directly into the open heater.

There are three identical feed pumps, each rated at 1200 g.p.m. and 2500ft head. The principal pump is driven by a steam turbine and an electric motor. The other pumps are motor driven only and intended for standby service. The turbine drive for the main feed pump receives steam from the 150 lb per square inch gauge header and discharges it to the 5 lb per square inch gauge header. A back pressure regulator controls the flow of steam to the turbine, thus varying the load. Normally, the motor connected to the other end of the pump shaft is lightly loaded or just floating on the shaft, but whenever the flow of steam to the deaerator falls below that required for full pump power, the motor picks up load.

The feed-water flow includes that which is necessary for steam production, plus approxi-

mately 1 per cent for continuous blowdown. The blowdown is flashed at 50 lb per square inch gauge and is piped into the 50 lb per square inch gauge header.

Air Compressors.—Two compressors are installed, one in the turbine room and the other in the mill. They operate at approximately 110 lb per square inch gauge and supply all of the plant's service air requirements. In addition, a recovery air compressor, working at 350 lb per square inch gauge, is located in the turbine room for use by the recovery boiler air soot blowers.

For instrumentation air, one instrument air compressor is located in the turbine room and two in the machine room. The compressor receivers are connected together so that all three are available for either mill or power instrument use, and are fitted with air dryers. These compressors are of the "carbon ring" type so as not to introduce oil into the system.

Controls.—The control of the recovery boiler is essentially manual with the exception of a furnace draught control which operates the induced draught fan hydraulic coupling. The rapping cycle of the electric precipitator is automatically controlled.

The bark boiler is fired by manually controlling the feeder screws. An oxygen recorder is used to control the excess air, and a furnace draught controller regulates the induced draught damper. There are also air and gas flow controls for the firing of natural gas.

The power boilers are primarily controlled by the pressure in the main steam header. This enables the power boilers to produce whatever steam is required above the production of the recovery and bark units. These boilers have automatic controls for the firing of natural gas, and remote manual controls for the firing of fuel oil. All of the steam generators in the plant have automatic three-element feed-water controls.

Electrical Equipment.—For full-scale production of the mill, approximately 37,000kW of electric power is required, of which 20,000kW are used for the wood grinding. This is obtained from the two turbo-generators, supplemented with 17,000kW from the T.V.A. system. Normally, the turbines operate in parallel with the T.V.A. system, but the systems can work independently with the power from the T.V.A. being utilised in the groundwood area, and the turbo-generator output in the rest of the mill. If necessary, enough T.V.A. current can be provided to permit full-scale operation of the mill with one of the generators out of service.

Electric power at 13,800V, three-phase, 60 cycles, is distributed throughout the mill to the various load centres for conversion to utilisation voltages. The power supplied by the T.V.A. system is delivered to the grinder room substation, where two 15,000kVA, three-phase transformers supply 4160V for the eight 4500 h.p. unity power factor synchronous motors driving the grinders ; and two 750kVA substations supply 460V for auxiliary motors. The power generated by the two 10,000kW turbo-generators is distributed at 13,800V to the wood yard, pulp mill, bleaching, stock preparation and machine room areas, where it is transformed to 460V for motors up to 200 h.p. and 2300V for motors from 200 h.p. to 1000 h.p. The two turbo-generators and the T.V.A. system are interconnected through a synchronising bus, with complete system control located in the power plant.

The primary control equipment is arranged for simplicity and convenience of operation as well as for safety of personnel, together with provision for isolation of power sources and sectionalising of the load for other than normal operating conditions.

The equipment was selected on the basis of continuous current rating together with the short circuit kVA available at the point of utilisation, the whole being co-ordinated to a 500,000kVA level. This co-ordination was extended in the selection of unit substations to permit the use of 150,000kVA high interrupting capacity motor starters for the 2300V motors and of combination magnetic starters in motor control centres for the 440V motors.

Use of unit substations together with low-voltage motor control centres practically eliminates any low-voltage power distribution. In the case of 2300V equipment, the motor starters form the low-voltage section of the substations ; hence the motor loads constitute the 2300V wiring. For the 440V wiring there are only short stub feeders to the motor control centres, and the motor loads make up the balance. Local control of the motors is accomplished with push-button stations placed at the machines with the individual starters in isolated control rooms together with the unit substations.

Motors are in general of conventional design, except perhaps the grinder motors, which are enclosed with built-in air coolers, and the paper machines, which are powered by electronically controlled, variable-speed sectional drive, including multiple generator-motor generator sets and 500V d.c. adjustable speed, enclosed, separately ventilated section motors.

The plant lighting system is sectionalised according to departments and locally controlled. Power is obtained from the 750kVA unit substations of the general power system and distributed at 460V to the areas, where it is transformed to 115/230V for the lighting units.

Recovery.—For the evaporation of the surplus black liquor from the kraft mill, a six-body, sextuple effect evaporator has been installed. The unit has sufficient capacity to evaporate 173,000 lb of water per hour, using 34,500 lb of steam per hour at 35 lb gauge. To condense the vapours from the sixth effect, a vertical surface condenser is used and consumes 1800 gallons of water per minute at 70 deg. Fah. with a temperature rise to 110 deg. A soap skimming tank with a paddle skimmer removes the soap from the liquor between the third and fourth effects.

The chemical recovery unit for the burning and reducing of the dry solids contained in the black liquor can burn 950,000 lb. of solids per twenty-four hours, and can raise 123,200 lb of steam per hour at 875 lb. per square inch and 825 deg. Fah. from feed water at 280 deg. Fah. Preliminary evaporation in the unit is through a cascade evaporator having wheels 14ft diameter by 9ft 6in face. Both forced and induced draught fans are driven by motors with hydraulic couplings for speed control.

There is an air puff system for soot blowing in the collector zone and the economiser passes, consisting of sixteen heads, are automatically controlled for sequential operation. In addition, there are twelve retractable soot blowers for clearing the screen tubes and superheater elements, all arranged for double side installation at six locations. These units are air operated with superheated steam for the cleaning medium.

A pneumatic system is used to unload salt cake from cars and deliver it either into storage or the feed hopper of the unit.

For the recovery of salt cake and dust in the flue gases an electric precipitator is furnished and installed as an integral part of the recovery building above the cascade evaporators. The unit consists of two electrical precipitators enclosed within a shell structure of combined hollow tile, steel, and reinforced concrete. Each of these units has an individual stack and is so arranged that with one of the units down the other can still be maintained in operation. The recovered salt cake from the precipitator is collected and dissolved in four wet bottom pans, through which concentrated liquor is circulated and its chemical strength built up.

Causticising.—The causticising plant consists of the following conventional systems : green liquor clarification, dregs washing, lime slaking, white liquor clarification, and lime mud washing. The design capacity is 30,200 cubic feet per day of white liquor, with 8 lb per cubic foot of total alkali and 7 lb per cubic foot of active alkali, all expressed as Na_2O with a sulphidity of 30 per cent. The plant can be operated at up to 38,000 cubic feet per day. The white liquor clarifier and lime mud washer are of the multiple tray design, while the green liquor clarifier and dregs washer are of the single tray design.

Lime Reburning.—The lime reburning plant consists of a rotary lime kiln, 9ft diameter by 250ft long, with four supports. At the feed end a vacuum mud filter and a slurry feeder provide a constant rate of feed. The kiln is fired by natural gas and has a capacity of approximately 80 tons per day, but can be operated up to approximately 125 tons per day to handle peak loads and additional production. Limestone is used as make-up and is introduced by a table feeder to the kiln feed conveyor. The limestone is stored in an overhead storage bin holding 47 tons, and another 100 tons can be stored on the ground. The handling system consists of a track hopper, drag chain conveyor, bucket elevator and necessary chutes.

Water Supply and Treatment.—The raw water for plant uses is obtained from the Hiwassee River, about 2½ miles above the plant site. Three vertical submerged pumps, each having a capacity of 6000 gallons per minute each, pump the raw water through 12,000ft of 36in lined and coated steel pipe to a treating plant located on a hill above the plant site. This is a modern gravity filtration plant utilising flash mixing, mechanical flocculation, settling and rapid sand filters. The clear well for the plant consists of an open, sloping side, concrete-lined reservoir with sloping sides, holding 4,000,000 gallons. Rated capacity of the water treatment plant is 25,000,000 gallons per day. The lower section of the clear water storage reservoir is reserved for fire protection. Due to the elevation of the clear water reservoir, a gravity flow is obtained and no service water pumps are required at the treating plant.

Waste Disposal.—The waste disposal system for the mill consists of a pump house for elevating the process waste to a primary settling basin. Secondary treatment is obtained in a large disposal reservoir with a detention capacity of approximately twenty-four days for the entire mill process waste. The sludge from the primary settling basin is pumped to a permanent disposal area of 25 acres, located in a ravine on the mill property. The primary settling basin for the disposal plant consists of an earth-lined reservoir with sloping sides, fitted with a mechanical rotary type sludge collector. The system can be enlarged if the mill capacity is later increased.

Piping and Instruments.—Plain black steel pipe is used through the digester, wash room and recovery area, also for the feed water and hot condensate service. In general, "Transite" pipe is used for all stock and white water piping after the washed stock storage chest, and for the ground wood and stock furnish up to the metering stuff boxes of the paper machine. From the metering stuff boxes to the machine and for the overflow from the screens the pipe is stainless steel. For the chlorination stage of the bleach plant rubber-lined pipe is installed ; for the caustic stage black steel pipe is used ; and for the hypo stage stainless steel.

Stock lines are fitted with Ferguson and Saunders valves ; for black liquor lubricated plug cocks and stainless trim gate valves are used ; and for white water in the machine room all-bronze or stainless steel gate valves.

Controls for the various divisions of the plant are mounted on panels centrally located on the operating floor in each building.

Buildings.—Foundations are cast in place on 40 tons capacity concrete piles. Lighter structures, tanks, &c., have been placed on reinforced concrete spread footings with soil values of 2500 to 3000 lb per square foot. Approximately 7200 piles were required. Approximately 8000 tons of steel were required for buildings and major structures, which are bolted throughout with high-tensile bolts. For the roof, level precast concrete slabs were used, with provision to maintain 2in of water on roof surface for summer insulation. Paper machine, pulp drying and stock preparation rooms also have 2in rigid insulation.

Exterior walls of all manufacturing buildings are red common brick, with a small amount of yellow. Internally, colour dynamics have been applied to a considerable extent, particularly on equipment. In conjunction with this, several shades of interior tile have been used. The basic interior colour of the walls is that of buff salt-glazed tile, while in the main machine rooms buff ceramic glazed tiles have been used with contrasting areas of green. Structural steel column flanges and like portions of the building actually forming part of the wall surfaces have been painted to match the tile areas. Exposed structural steel has in general been painted yellow to blend with the basic tile colours.

Belts of glass block are used wherever required for lighting, with small vision panels at eye height at selected points, and adjustable alumi-

nium louvres are used for ventilation. Floors are reinforced concrete or welded steel gratings, and four elevators are provided.

The main manufacturing buildings are 1200ft long and cover approximately 6 acres under the roof. The power plant is 200ft square and covers about 1 acre under the roof. The highest structures are the recovery room, approximately 115ft above ground level, and the bleach plant about 95ft high.

General Facilities.—A two-storey building for shops and stores of 40,000 square feet total floor space is located on one side of the grinder and stock preparation rooms parallel to the servicing tracks. Adjacent to the utilities building of 12,000 square feet is a paved parking area for 600 employees' cars. Mill offices of glazed tile are mainly located at one end of the shops and stores building where they are central to the mill. There are other offices on the mezzanine floor at the finishing end of the machine room, and a laboratory of glazed tile is located at one end of the stock preparation room.

The main utilities building provides facilities for watchmen, first aid, reception room, credit union, personnel office, time and pay roll offices, also a main locker room and a cafeteria with a large conference room adjoining it.

The Southern Railway serves the site with a spur track about 1500ft long from the main mill line near Calhoun to the mill gate. Inside the mill area there is approximately 18,000ft of track. For warehousing, five buildings, each 40ft by 100ft, have been erected for permanent storage and were supplemented by five additional units for temporary construction purposes, giving a total of 40,000 square feet of storage.

Mechanical Wagon Marshalling System

A MECHANICAL system for handling and unloading wagons has been developed by Mitchell Engineering, Ltd., of Peterborough and London. Compared with the conventional "balloon" sidings, its chief advantages are stated to consist in its needing much less space—about one-half—and in not requiring any man-handling or shunting by locomotive. In this way safe day and night operation is possible in any kind of weather, and at a greatly increased rate of turnover.

At the British Electricity Authority's power station at Freemens Meadows, Leicester, two men are required for weighing, discharging and marshalling forty wagons of 20 tons each per hour. The sidings are shown in Fig. 1. There are four parallel tracks, each about 700ft long, including turnouts; three of them being reception sidings each holding thirty-five wagons. These are on a down gradient and terminate at a traverser, while the fourth siding has at its lower end the wagon tippler, followed by a booster track some 250ft long. The remainder of this track has a slightly rising gradient ending in a kick-back, the turnout from which leads back to the reception sidings. Incoming trains are left against the No. 1 stops (see diagram) and are uncoupled. From the control cabin the operator selects the sidings to be worked and starts the automatic unloading sequence. The first wagon is released and rolls towards the No. 2 stop, while the traverser moves to the siding concerned. Inside the main track on the traverser, and extended into the sidings as far as the No. 2 stop, is a narrow-gauge track carrying a trolley. This moves out and by means of an arm engages with the front axle of the wagon, simultaneously releasing the stop. It then brings the wagon back with it on to the traverser, locates it and resets the stop. As the wagon is traversed to the tippler track and pushed out on to the tippler by the trolley, the next wagon rolls forward to the No. 2 stop. The operator, by pressing a button, weighs, tips, and rights again the wagon. It is then re-weighed, and pushed by the next incoming wagon down a short incline to the booster (see Fig. 2). This consists of a rope-hauled trolley, which engages with the rear axle and automatically accelerates the wagon up an incline to the kick-back, from which a spring-loaded trailing turnout and automatic points send it back to its original siding. When all the wagons on a siding have been unloaded they are recoupled and taken away by a locomotive.

The gradient between booster and kick-back is such that any wagon not sufficiently accelerated to reach the kick-back stops in the section. Particularly free wagons are prevented from rolling back into the booster by automatically being switched into sand. If the booster fails while a wagon is on it, self-setting chocks prevent running back.

A second installation is at the central coal preparation plant of the National Coal Board at Dalkeith. It handles forty wagons of 10 tons per hour. These are emptied by two tipplers and weighed. They then roll under gravity to sets of stops, from where they are fed one at a time to the first traverser, and distributed to the eight loading tracks. Leaving the traverser under gravity, they come to rest in a dip in the tracks, and are moved by rope-driven haulage mule to the loading point. Even filling is achieved by "inching" the wagons under a boom loading conveyor, the haulage controls comprising forward, reverse and stop, and inching both forward and reverse. Full wagons are pushed down an incline by the following empty ones to a second traverser, which has a weighbridge opposite one of the tracks. After weighing, the wagons are distributed to the outgoing sidings for making up into trains.

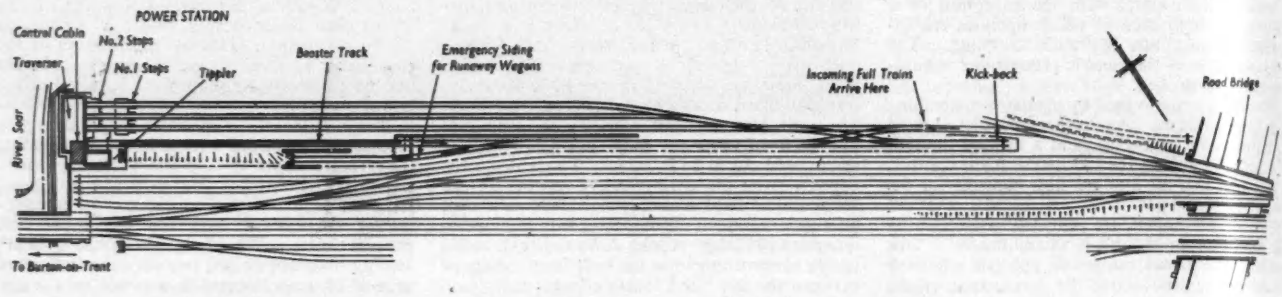


Fig. 1—Wagon marshalling at Leicester Power Station The length of the sidings was limited by the distance between the river and the road, about ¼ mile

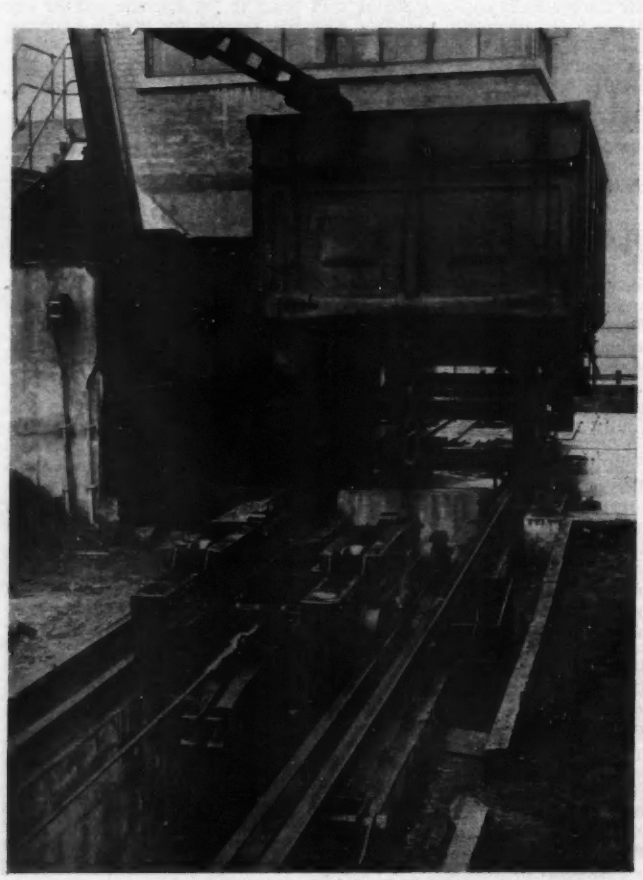


Fig. 2—Mechanical marshalling at Leicester power station. A wagon standing on the tippler with the booster mule in the foreground

Engine Starter for Fighters

A STARTING system for turbo engines has been developed by The Plessey Company, Ltd., Ilford, Essex, which makes use of a liquid monofuel, iso-propyl nitrate. This is classed as a safe fuel; not being sensitive to shock, it can be transported in ordinary goods vehicles, subject to normal fire precautions. Tests have shown that tanks filled with iso-propyl nitrate cannot be detonated by gunfire.

It is claimed that the system is smaller and cheaper than an equivalent cartridge starter, and that it can start the engines of a "Meteor" fighter in twenty seconds. Two of our new fighters will be equipped with it and licences to manufacture have been granted in U.S.A. and Sweden.

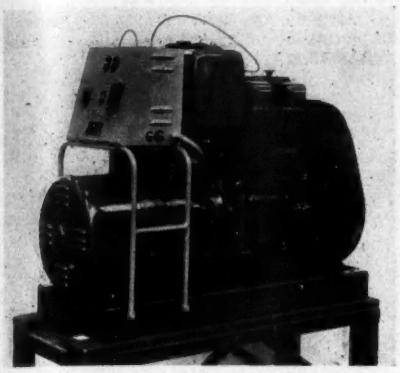
Although this starter has been developed primarily for fighter aircraft, some of its advantages are stated to apply equally to multi-engined machines, both military and civil. It is extremely light-weight and a starter motor only need be fitted to each engine, with a common fuel and control system for all the starters.

By keeping the aircraft independent of a ground source of power, considerable saving in engine fuel can be effected during taxying, as the engines can be shut down when the aircraft is held at the end of the runway.

Automatically Controlled Generator Set

A DIESEL-DRIVEN alternator set which can be operated either manually, by remote control or fully automatically, has recently been put on the market by Arthur Lyon and Co. (Engineers), Ltd., of Stamford, Lincs.

The set is available in two sizes, 2·5kW and 5kW, giving single-phase alternating current at 230V. The power unit is a Petter vertical, four-stroke diesel with one or two cylinders. It is air-cooled and has a governed speed of



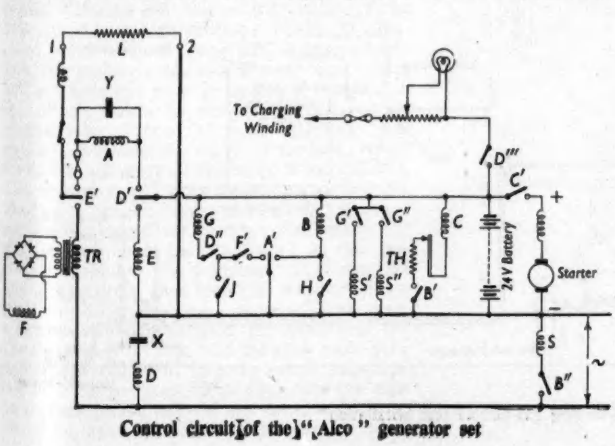
Generator set showing flange-mounted assembly of generator on engine. The control box is above the generator

1500 r.p.m. Full-load fuel consumption is stated to be 0·21 gallon per hour for the 2·5kW set and 0·5 gallon per hour for the 5kW set.

The alternator is self-exciting and self-regulating, and is provided with auxiliary starting and battery charging windings. It is fitted with ball bearings and the protected housing is flange mounted on the engine crankcase, forming an integral unit which rests on anti-vibration mountings on a fabricated frame. This stops vibrations being transmitted to the base or to the control gear. The control box is fixed to tubular uprights on the main frame. The controls include two solenoids which operate the decompressor lever and fuel rack through flexible cables. The standard equipment includes an air cleaner, silencer, wall-mounted 15-gallon fuel tank, and auxiliary starting handle.

Control of the unit can be by hand start, electric start, remote control or fully automatic control. The automatic system is normally set to cut in when a load of at least 60W is connected, but this figure can be reduced to 15W in certain cases. The engine is shut down when the last load is switched off.

The automatic control circuit is shown in the diagram and functions as follows :—When the minimum load *L* is switched on to terminals 1 and 2, relay *A* is energised from the 24V battery and closes the contacts *A′* towards *B*. These are normally closed towards *G*. Relay *B* operates relay *C* via contacts *B′*. The latter closes the contacts *C′*, thus motoring the engine. Relay *B* also closes the contacts *B″*, which connect the solenoid *S* across the a.c. line. When the a.c. voltage reaches 25V this solenoid, by means of a Bowden cable, puts the engine over to compression. At the same time, it unlatches the fuel rack. The engine then fires and runs up to speed. When a voltage of 150V is reached, relay *D* disconnects the contacts *D′* from *A* and connects to relay *E*. In turn, *E* disconnects *E′* from *A* and connects to the transformer winding *TR*, thus throwing the load over to alternating current and also energising the relay *F* by means of rectified current from the saturated transformer *TR*. At the same time, relay *D* closes contacts *D″* and thus prepares the circuit for relay *G*. When the last load is switched off relay *F* closes the contacts *F′*, thus energising relay *G*, which in turn operates the decompressor solenoid *S′* and fuel cut-off *S″* via contacts *G′* and *G″*. These mechanically latch together and remain latched after *D* has opened. The condenser *X* in series with *D* is a tuning condenser to prevent the operation of *D* at very low frequency. Should the engine fail to start after thirty seconds' motoring, the thermal cut-out *TH* opens and disconnects the starter winding from the battery by cutting off *C* and thus opening *C′*. The thermal cut-out must then be reset by hand before the engine can be started again. An additional contact *D‴* operated by *D* connects the battery to the charging winding via a fuse and indicator light. The condenser *Y* is of sufficient capacity to hold *A* in for a short period, so that there is no overlap between the starting and stopping circuits. Switches *H* and *J* provide for manual starting and stopping.



Control circuit of the "Alco" generator set

Adhesive "Redux" Film

THE "Redux" bonding process, introduced by Aero Research, Ltd., in 1942, has now been used in some forty different aircraft, and service under flying conditions covers a period of over ten years.

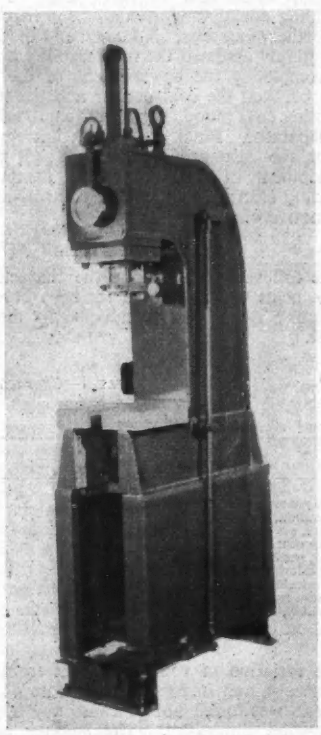
The introduction of the "Redux" adhesive in the form of a film which should contribute towards greater ease and economy in use, is now announced by Aero Research, Ltd. It consists of the identical "Redux" liquid and powder supplied as a film expressly, but not exclusively, for bonding metal skins to metal honeycombs to make the sandwich structures in which leading aircraft makers are now showing interest. "Redux" film, which is covered by specification DTD.775 A, is supplied in rolls with protective covering and has a storage life of at least six months. For binding panels to honeycombs, it is first consolidated on to the metal skin under heat and vacuum pressure, with a sheet of aluminium foil placed between the film and the rubber blanket to prevent sticking to the rubber. The heating time for this operation is ten minutes at 145 deg. Cent. After cooling, the aluminium foil is stripped off and a coating of "Redux" 120 applied by brush over the partially cured film. "Redux" 120 should also be applied to the edge of the honeycomb. The "Redux" 120 is dried at 80 deg. Cent. for thirty to sixty minutes before assembling skins and honeycomb and curing the adhesive at 145 deg. Cent. under vacuum pressure. The curing time will depend upon such factors as the thickness of the honeycomb and may be assumed to be about one hour for a ¼in thick honeycomb core sandwich, heated one side only.

Tests to destruction at room temperature have shown the failing load on lap joint specimens cured under vacuum at 12 lb per square inch to be of the order of 4100 lb per square inch (specimens : 20 S.W.G. DTD.546, 1in wide and ½in overlap, pickled to DTD.915 A for one hour at 60 deg. Cent., cured for thirty minutes at 145 deg. Cent.).

An important advantage of "Redux" film is that it ensures exact control of the proportions of powder and liquid in the bond and it has resulted in improved strength at elevated temperatures. It can be used for normal metal-to-metal bonding processes, as, for example, in stringers to skins, and the curing time is thirty minutes at 145 deg. Cent. It may be expected, however, that the main uses of the film will lie in the bonding of skins to honeycomb cores (for which purpose an adhesive is essential). It is noted that in neither application is any priming of the metal surfaces required before application of the adhesive.

15-Ton Hydraulic Press

THE hydraulic press of 15 tons capacity which we illustrate below is now being made by Pilot Works, Ltd., Manchester Road, Bolton, Lancs. It has a stroke 8in long and the working pressure can be varied from 1 ton to 15 tons by adjustment of a small handwheel. The press frame is



Hydraulic press with variable capacity from 1 to 15 tons and an 8in stroke

of fabricated steel plate construction and is designed to give a daylight of 16in with a throat 8½in deep.

The twin cylinder, high pressure hydraulic pump of the press is driven by a 4 h.p., 950 r.p.m. motor, and the circuit is arranged to give variable operating speeds. The full down stroke of 8in can be made in two and a half seconds and a quick ram return in one-and-a-half seconds. Ram movements are controlled through two pedals, one for the working stroke and the other for the return movement.

The heavy steel bedplate of the machine measures 12in by 14in and it has a central slot 2½in wide by 7in long. This bed is bolted on the frame and can easily be removed to permit the attachment of special tools or fixtures.

CARGO HANDLING ASSOCIATION.—We are informed by the International Cargo Handling Co-ordination Association that its United Kingdom National Committee intends to hold a Symposium on October 28th, in London. The subjects to be dealt with will be "Accident Incidence in Ports" and "Multiplicity of Marking of Cargoes."

Coal-Burning Gas Turbine

(By Our American Editor)

The Locomotive Development Committee of Bituminous Coal Research, Incorporated, at Dunkirk, New York, has now accumulated over 2000 hours of operating experience with full-scale direct-fired coal burning gas turbines. About half of this test work was conducted on an " Allis-Chalmers " 4250 h.p. gas turbine power plant designed to fit within the cab contour limitations of American railway locomotives. The present report reviews the current performance of the test installation and describes certain changes which have been made in the coal handling and preparation gear and the ash separation equipment.

RESEARCH work being conducted on the 4250 h.p. gas turbine power plant at Dunkirk, New York, is a joint venture between the Locomotive Development Committee (L.D.C.) of Bituminous Coal Research, Incorporated, and the American Locomotive Company (A.L.C.O.), the latter firm having become a partial sponsor of this scheme last year. As a result of this joint sponsorship, the responsibilities relating to the current work have been assigned as follows : The L.D.C. has accepted responsibility for developing methods for supplying the proposed locomotive with suitable coal—cleaned, dried and properly sized—and for providing coal handling equipment to conduct the forthcoming tests. A.L.C.O. and the L.D.C. have jointly assumed the responsibility and cost for completing the development of the equipment between the coal bunker and the turbine, including coal pump, pulveriser, combustor and ash separator. Finally, A.L.C.O. has agreed to accept the responsibility and cost of further development of the gas turbine components, including electrical equipment, controls and the locomotive chassis.

Gas Turbine Coal

The following table shows the characteristics of the coals which have so far been burned in the course of the tests conducted by the committee.

Table I—*Characteristics of Coals Used in L.D.C. Tests*

Coal identification	Pittsburgh seam bituminous		Lignite	Pocahontas
Source	Willow Grove	Valley Camp	Australia	W. Virginia
Volatile content, per cent	39·5	36·3	45·5	20·4
Fixed carbon, per cent	49·1	52·4	44·1	70·7
Moisture, per cent	2·6	1·6	8·5	0·9
Ash, per cent	8·8	9·7	1·9	8·0
Sulphur, per cent	3·9	2·2	0·2	0·4
Higher calorific value, B.Th.U. per lb	13,210	13,430	10,100	14,446
Lower calorific value, B.Th.U. per lb	12,690	12,945	9,635	14,000
Ash fusion temperature, deg. Fah.	2,440	2,680	2,750	2,350
Grindability, Hardgrove	68·5	65	—	110

The variation in volatile content from 20 to 40 per cent, and in fixed carbon from 44 to 71 per cent, was found not to cause any apparent combustion difficulties. The sulphur content has varied from 0·2 to 4 per cent with no adverse effects upon the combustion or ash removal equipment. The range of ash fusion temperatures from 2350 deg. to 2750 deg. Fah. have caused no difficulty. The chemical nature of the ash has proved to be unimportant, since the normal constituents of coal ash are harmless to turbine materials. The ash content of the coal is considered to be an important factor and low ash coals are obviously preferable since they reduce the load on the separating equipment. The heating value of the coal is significant only as it affects the fuel cost and as it is reflected in the required capacity of the bunkers and feeding equipment.

The original goal of the Locomotive Development Committee was a completely self-contained power plant which would operate satisfactorily with any kind and size of bituminous coal. In the light of the operating experience obtained, it now appears that little if any restriction need be placed on the kind of coal, but a more realistic requirement must be established for the size consist and the moisture content. It is felt that somewhere between the coal seam and the gas turbine combustor, the coal must be reduced to a dry, free-flowing powder containing no more than 5 per cent of particles which are larger than 100 mesh. When it reaches the locomotive, the coal should be in such condition that it can be handled entirely by pneumatic equipment without the necessity of resorting to a mechanical conveyor.

The ability to handle the coal on the locomotive with pneumatic rather than mechanical conveyors imposes limitations on the size consist. The experience gained by the L.D.C. has shown that coal which is ¼in in top size can be handled readily with " Airslide " pneumatic conveyors, provided that it contains a substantial percentage of −200 mesh particles. In a test, a quantity of ¼in by 0 air-cleaned coal, which was procured from a modern coal preparation plant, proved to be difficult to handle by the " Airslide " conveyor, because the −200 mesh fraction was only 3 per cent. When this coal was put through a hammer mill with ¼in screens, the resulting product was conveyed without difficulty by the " Airslide " conveyor, since the −200 mesh fraction had been increased to 34 per cent. Since the hammer mill reduction process is relatively inexpensive, ¼in by 0 coal, suitable for use with pneumatic conveyors, can readily be prepared from the ⅜in by 0 coal which is widely available in America. It appears that this ¼in by 0 dry coal would constitute a suitable gas turbine fuel, provided that a pulveriser is used between the coal pump and the combustors. In one proposed system, the locomotive coal bunker would be loaded with dry coal in the ¼in by 0 size range, and this coal would be fed from the bunker to the coal pump by means of a pneumatic conveyor. The coal would be pulverised under pressure on being conveyed from the pump to the combustor. There would be no storage of pulverised coal, and a " Riley " high-speed attrition mill would be used.

Coal Preparation

The equipment used to supply the pulverised coal to the gas turbine plant during the current test work has been rearranged to obtain separation between the coal processing unit and the turbine feed pump.* As shown in Fig. 1, the output of the " Babcock and Wilcox " pulveriser is delivered through a cyclone separator into a 7000 lb capacity storage tank. The air from the separators is vented through a " Pangborn " dust collector, where the fines are caught. A screw conveyor returns these fines to the pulverised coal storage tank. An " Airslide " pneumatic conveyor is mounted in the bottom of the storage tank to transfer the pulverised coal to a 1000 lb capacity feed tank which is supported on scales. The ærating feeder and rotary coal pump are mounted beneath the coal feed tank. These changes were made to add storage capacity to the test system, thus allowing the pulveriser to operate in a more efficient manner, and also providing several hours of reserve coal supply. The addition of the scales supporting the pulverised coal feed tank now allows the rate of coal feed to the combustors to be determined accurately. The coal feed tank has been modified slightly, but is essentially the same as the arrangement used during the earlier 750 hour test. The rotary coal pump is now driven by a " General Electric " variable speed, d.c. motor, instead of by the hydraulic transmission which was originally used. This electric transmission allows a very fine control of the coal pump speed.

The Rotary Coal Pump

The tests conducted to date have established that the L.D.C. rotary coal pump is a reliable device for delivering pulverised coal into a conveying air line operating at a pressure of 100 lb per square inch. One of the pumps was in service without requiring maintenance for 575 hours. The rotary coal pump, which is illustrated in Fig. 2, consists essentially of a rotor which turns within a casing, carrying pockets of coal from the atmospheric pressure intake to the high pressure discharge point. The pump uses an eighteen-pocket rotor, 5in wide and 12in in diameter. The casing is formed

* A diagram of the original arrangement of the gas turbine test installation may be found in THE ENGINEER of November 14, 1952, page 644.

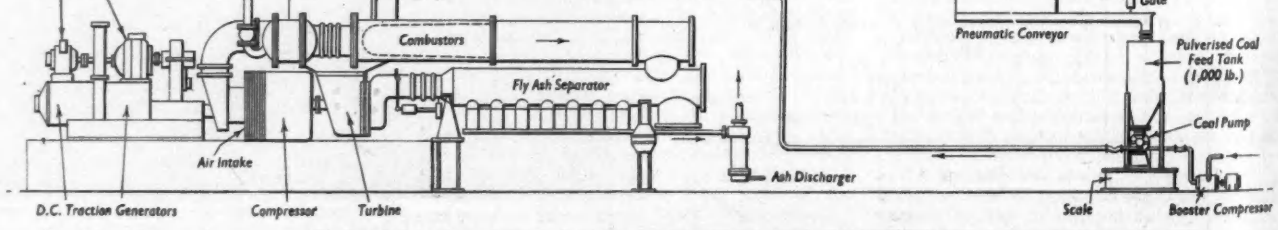


Fig. 1—Present arrangement of L.D.C. coal-burning gas-turbine test installation

by a central ring and two side brackets, which contain the rotor bearings. The clearances between the rotor and the casing should not exceed 0·003in. With this clearance, the leakage of air and coal has been found to be sufficiently low to allow the pump to function at pressures up to 150 lb per square inch. The power required to drive the pump ranges from 1 h.p. at minimum speed to 3 h.p. at maximum speed. Tests which

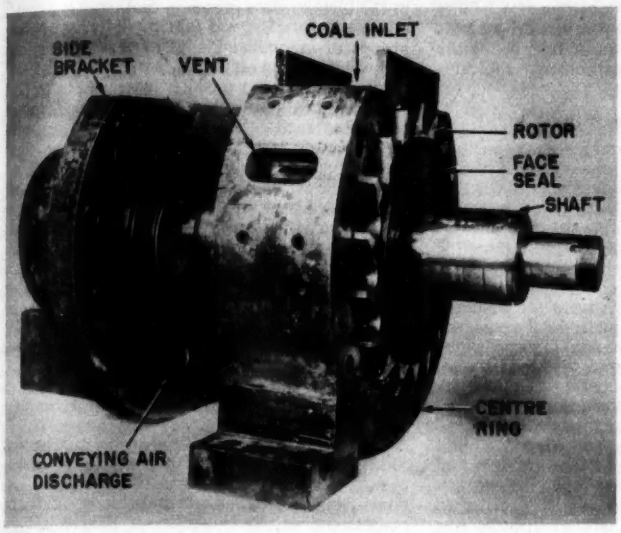


Fig. 2—Assembly of L.D.C. rotary coal pump

were run with pulverised coal to determine the capacity of the pump at various rotative speeds and discharge air pressures have indicated that for any given air pressure, the capacity of the pump increases directly with speed up to approximately 50 r.p.m. Above that speed, the capacity falls off. As the pressure increases at any given speed, the capacity diminishes, since the amount of leakage increases directly with the pressure, reducing the amount of coal which can fall into the pockets. The capacity of the pump at a discharge pressure of 75 lb per square inch is approximately 4000 lb per hour, which is adequate for the current test programme. At this feed rate, the turbine without the regenerator will produce approximately 3600 s.h.p. at an ambient air temperature of 80 deg. Fah. At the lower temperatures which will prevail during part of the current turbine tests, the turbine output at this coal flow will exceed 4000 s.h.p.

The Ash Separator Tube

During the first 178 hours of coal-fired operation of the "Allis-Chalmers" 4250 h.p. gas turbine, no damage was done to the turbine blading by erosion. During this period ash samples taken from the exhaust stack showed no particles larger than 20 microns in diameter. Operation during this period was at half load or less, and the fly ash separator apparently functioned at maximum efficiency during the entire period. During the first seventy hours of the 750-hour test, a leak occurred within the separator, which allowed coarse ash to pass directly into the turbine. Serious erosion took place and ash samplers were immediately installed in the turbine inlets to detect the presence of erosive ash. When full load operation was resumed, following the repair of the leak, it was found that ash separation was quite inconsistent. The separator efficiency began to deteriorate after a few hours of operation and the separator manifolds plugged frequently. No reason for this plugging could be found until, at the conclusion of the test, the separator was dismantled and obstructions were found in the blow-down manifold lines. In the course of last year, attention was concentrated on improving the Dunlab separator tube and building multi-tube separation equipment of a new and improved design. The performance of each tube can now be checked individually at any time, and instrumentation has been added to the plant to allow the overall performance of the separator to be checked continuously.

The present Mark III Dunlab separator tube originated from the Mark I Dunlab tube, with which hundreds of tests were run at the maximum turbine operating temperature of 1300 deg. Fah. It was found that the "razor plate" which characterised the Mark I tube did not aid the efficiency of the simple cylindrical separator with tangential blow-down and it was therefore discarded. After a number of attempts to find a blow-down arrangement which could not be plugged by a large ash fragment, the annular blow-down was developed. The gap between the lower end of the tube and the bottom plate can be made as narrow as ¼in without reducing the collection efficiency; the blow-down line is ¾in in diameter. Thus, a particle big enough to plug the blow-down line cannot pass under the lip, but will instead remain in the tube until it is reduced to a size small enough to allow it to pass under the lip and out through the discharge tube. Tests were run with various modifications of this blow-down in which all of the dimensions of the tube were varied systematically. It was found that the original 27in Dunlab tube length was satisfactory, while the optimum length of the cleaned air discharge tube was found to be 10in. The exact dimensions of the annulus were found to be relatively unimportant. The annulus as well as the remainder of the tube can be inspected at any time by removing the bottom cover. After the optimum dimensions of the Mark III tube had been established, a final series of tests was run at 1300 deg. Fah. with varying air flows and blow-down flows, and satisfactory results were obtained.

It is now believed that the loss in efficiency which occurred with the Mark I tubes during the 750-hour test was caused by a gradual reduction of the blow-down flow below the 10 cubic feet per minute required for maximum efficiency. In order to prevent a recurrence of this situation, attention was given to developing a method of measuring the blow-down flows without interfering with the operation of the tube. The use of a casting for the annular bottom offered an opportunity to determine the flow through the blow-down line by measuring the pressure drop from the elliptical section, where the line leaves the annulus, to the ¾in diameter circular section at the connection to the blow-down pipe. A manometer connected across these taps gives a pressure drop reading which depends upon the quantity of air, or air and dust, flowing through the blow-down pipe. A manometer has been provided for each of the twenty-six separator tubes in the two multi-tube separators and an important precaution in the current operating tests is the constant observation of these manometers to make sure that every blow-down line is operating properly at all times.

The Multi-Tube Ash Separator

As previously mentioned, a number of difficulties were experienced during the earlier operation of the ash separating plant. A serious leak occurred in one of the partitions separating the cleaned air from the dust-laden inlet air; this leak caused the first serious turbine blade erosion. In addition, it was impossible to check the performance of the individual tubes during operation and the removal of obstructions could be accomplished only by shutting down the entire plant and opening up the fly ash separator. In order to eliminate as many of these difficulties as possible, and to take full advantage of the design of the new Dunlab tube, new multi-tube separators have been designed and built in which the individual separator tubes are used as pressure-sustaining elements, and the large pressure shell has been eliminated. Since each of the two combustors discharges approximately 20,000 cubic feet of air per minute during normal turbine operation, at temperatures up to 1300 deg. Fah. and pressures up to 85 lb per square inch absolute, it was decided to construct two multi-tube separator assemblies, each using thirteen Mark III Dunlab tubes. The construction of one of the two separators is indicated in Fig. 3.

Each separator assembly consists of a 30in by 24in tee through which the heated air and ash enter. The gases and ash then make a 90 deg. turn, guided by a deflector, through the 24in diameter vertical section of the tee. A drop-out pot is placed beneath the tee to catch heavy ash particles. The fine ash particles and air then make another 90 deg. turn, and enter the body of the separator. The separator proper consists of a 28in diameter cylindrical section, which is divided into two parts by a diagonal slope sheet. The Dunlab tubes were welded to the lower part of the separator body and the slope sheet causes the ash-laden air to turn downward and enter

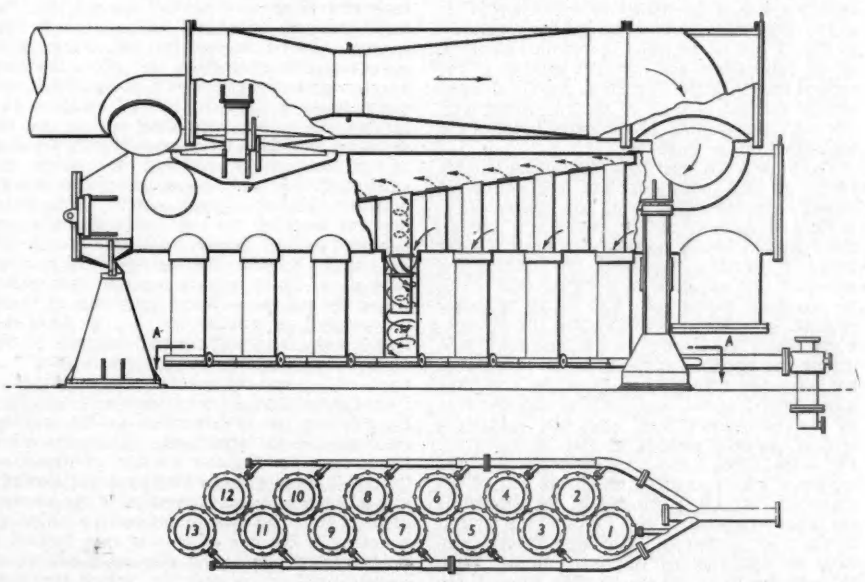


Fig. 3—Construction of multi-tube fly ash separator

the individual tubes. The cleaned air discharge tubes are inserted through the vaned sections which cause the dust-laden air to spin as it enters the tubes. As shown in Fig. 3, the ash particles in the spinning air stream are thrown by centrifugal force towards the wall of the separator tube. The particles are then carried out through the blow-down line while the cleaned air spins up through the discharge tube and proceeds to the turbine inlet. The discharge tubes are welded to the slope sheet, but are free to slide through the vaned sections, thus providing the necessary flexibility to permit the discharge tubes to expand and contract freely. The slope sheet is welded on both sides to the upper and lower sections of the separator body.

Because of the relatively small diameter of the separator body, the stresses in the shell are now low enough to permit the use of the more freely available " Incoloy " instead of the " Inconel X " alloy which was required on the original large diameter pressure shell. In order to give the necessary strength to the lower part of the shell, which is cut away to allow the air to enter the Dunlab tubes, ¾in thick " Incoloy " was used for the first 7in of each separator tube. The remainder of the tube was made from a columbium-stabilised stainless steel conforming to the Type 347 specification of the American Iron and Steel Institute. For the convenience of readers we reproduce herewith a table showing

TABLE II

Elements	American Alloy Specification				
	S-590	Inconel X	Incoloy	19-9-DL	347
Cobalt	20·0	—	—	—	—
Chromium	20·0	15·0	19–22	19·0	18·5
Nickel	20·0	73·0	32–36	9·0	11·0
Molybdenum	4·0	—	—	1·25	—
Tungsten	4·0	—	—	1·25	—
Columbium	4·0	0·8	—	0·4	0·7
Titanium	—	2·5	—	0·35	—
Carbon	0·4	0·04	1·0	0·3	0·07
Aluminium	1·65	0·8	—	—	—
Silicon	0·65	0·3	1·0	0·5	0·5
Manganese	0·75	0·5	1·5	0·75	1·0
Iron	24·6	7·0	40·2	67·2	68·2

the composition of the principal American heat-resistant alloys mentioned in this article.

Each of the two separators is supported upon two pedestals. At the turbine inlet end, each separator is bolted rigidly to a pedestal which extends upward from the platform of the test plant. The inlet end of each separator is supported by, but not bolted to, a floor-mounted pedestal. The weight of the separator is supported by rollers, which permit the shell to expand away from the turbine. The combustor casing and extension are bolted rigidly to the separator inlet flange, so that they also tend to move away from the turbine as the unit heats up. Since the temperatures and coefficients of expansion of the various components are different, they will expand at different rates ; this variation is accommodated by expansion joints at the combustor inlets. The end flanges shown in Fig. 3 can be removed to permit inspection of the combustors and the inlet sections of the separators. A large inspection port is situated near the outlet of each of the two separators. Through this opening the discharge tubes of the separators can be inspected.

The blow-down lines from the thirteen Dunlab tubes in each separator unit are connected through the manifolds to an ash concentrator. A flow of cold air can be established through the manifold line if necessary to keep it clear under all operating conditions. In addition, the manifold line has been so designed that it can be inspected during each step of the assembly process, in order to guard against the obstructions which developed in the manifold used during the previous test. In order to equalise the blow-down flow from all of the separator tubes, provision has been made to vary the area of the blow-down lines after the measuring section has been passed. It may be seen from Fig. 4 that tubes 1 and 2 are nearest both to the separator inlet and to the discharge end of the manifold. At the other end of the separator, the tubes numbered 12 and 13 are at the far end of the inlet section and also are farthest away from the discharge end of the manifold. Thus, the pressure drop causing the flow through the blow-down lines of tubes 1 and 2 will be considerably greater than the pressure drop causing the blow-down flow out of tubes 12 and 13. To counteract the natural tendency for the first tubes to supply most of the blow-down flow, while the last tubes supply virtually none, the bottom castings of the Dunlab tubes have been counterbored and stainless steel bushings of five different inside diameters have been provided. Bushings with minimum inside diameter will be installed in the lines from tubes 12 and 13. The pressure drop across the metering sections of the blow-down lines will continue to be a measure of the total amount of blow-down flow. If one of the blow-down lines becomes obstructed for any reason during operation, the pressure drop across the metering section of that tube falls below the normal value, and the manometer indicates which tube is in difficulty.

Erosion Detection

Last year a research programme was sponsored at the Armour Research Foundation in Chicago to establish new methods of determining whether erosive ash was being admitted to the coal-burning gas turbine. The principal criterion was speed of action, since the thirty-minute sampling periods used during the 750-hour test were much too slow to detect sudden changes in separator performance. Two methods were selected, the first utilising the change in electrical resistance of a sample exposed to erosion in the turbine inlet stream, while the second proposed to use irradiated " S-590 " alloy, containing cobalt-60, as a radio-active tracer to detect erosion.

The electrical resistance method was first tried at atmospheric temperature, and it was found that the resistance of a strip of platinum would change at a measurable rate when coarse ash was allowed to impinge upon it. In order to apply this method at the turbine inlet, it was necessary to compensate for temperature changes. This was accomplished by setting up a simple bridge circuit, in which one side of the bridge was the erosion test specimen, while the other side was an identical piece of platinum, shielded from ash impingement. This method was found to be feasible at atmospheric temperature, and tests were then started at 1300 deg. Fah. It was found that, at this temperature, platinum could be replaced by " Kovar," an inexpensive and readily available alloy containing approximately 54 per cent iron, 28 per cent nickel and 18 per cent cobalt. Coarse ash impinged upon the " Kovar " specimen at 1300 deg. Fah. causes its resistance to change six times as rapidly as fine ash impinged at the same velocity. This difference can readily be detected with simple electrical instruments and translated into a measure of relative erosiveness.

The successful use of radio-active tracer techniques in detecting the presence of extremely minute quantities of irradiated metal suggested that this idea might be adapted to a turbine erosion detector. Preliminary tests of a small irradiated target of " S-590 " showed that the metal removed by an ash-laden air jet in one minute could be detected because of the radio-activity of the cobalt-60 in this alloy. Further analyses showed that it would be feasible to use one or more irradiated " S-590 " blades in the turbine and to determine their erosion rate by sampling the ash in the exhaust stack. Because of the necessity for shielding the turbine, the irradiated blade method was discarded in favour of a less direct but simpler system. Samples of the ash entering the two turbine inlets are impinged at high velocity upon small targets of irradiated " S-590." The air stream is then led through a slowly moving tape of filter paper where the ash and removed fragments of metal are caught. A scintillation counter scans the tape continuously and the radio-activity of the observed portion of the tape is indicated in terms of " counts per minute." If the ash taken from the turbine inlet air stream is non-erosive, the counting rate is determined by the environment around the apparatus. If, on the other hand, even the slightest amount of irradiated " S-590 " appears on the filter tape, the counting rate goes up in direct proportion to the amount of metal presented each minute to the scintillation counter. If the rate of erosion rises beyond a predetermined limit, the electronic equipment sounds an alarm to warn the turbine operator. The particular advantage of the radio-active method is its speed and directness. Less than one minute is needed to detect the presence of erosive ash, and the actual amount of metal removed can be calculated readily.

New Turbine Blading

When the " Allis-Chalmers " gas turbine was inspected at the conclusion of the 750-hour test it was found that the first four rows of both cylinder and rotor blading required replacement, and the American Locomotive Company undertook the responsibility of providing the new blading. The stator blades originally supplied in the turbine were precision cast from " S-590 " alloy. The blading was fabricated by assembling groups of individual blades into ninety sections and welding them on the inner radius to " S-590 " rings. These rings were later machined to receive the inter-stage packing glands. The blades were welded to each other on the outer radius, and the assembly was then machined to the final dimensions. It was found that enough " S-590 " material was available to allow the casting of the cylinder blades. New inner blade rings were also required, since the original rings could not be rewelded with any expectation of maintaining the necessary close tolerances. The rings were forged in quadrants and rough-machined, after which the individual blades were welded to the segments. After the necessary heat treating for stress relief, and a careful " Zyglo " inspection, the welded quadrants were finish-machined. Finally, the finished segments were installed in the cylinder blade sections of the turbine and caulked in place.

The original rotor blading in the turbine was machined from " S-590 " bar stock. Precision casting had been considered but was ruled out when tests showed that cast blades did not possess the required ductility at 1300 deg. Fah. Forging was also considered but the " S-590 " alloy proved to be too tough at forging temperatures. Consequently, the blade shapes were developed by machining and the roots were produced by a " crush grinding " process. After giving careful consideration to the selection of both materials and production processes for the rotor blades, the operating committee decided to use " 19–9–DL " since it is an alloy which is readily available, and one with which the American Locomotive Company has had considerable experience. The company decided to manufacture the rotor blades by first broaching the roots and then generating the air-foil sections on a " Hydrotel " copy milling machine.

When the plans were made for the current turbine tests, the operating committee decided to alter the test plant by eliminating the regenerator. The primary purpose of this change was to enable the performance of the simple open-cycle plant to be determined, and a secondary consideration was to facilitate the inspection of the turbine blading at frequent intervals during the test programme. It was recognised that the removal of the regenerator would increase the fuel consumption of the turbine at its most efficient load of about 3200 h.p., but it was also anticipated that the maximum capacity of the machine would be increased by approximately 300 h.p. by eliminating the pressure drop caused by the regenerator. The speed range of the turbine during the earlier test proved to be considerably less than had been originally anticipated, and for that reason the regenerator had not given the expected reduction in low-load fuel consumption. Likewise, the pressure ratio at maximum speed proved to be approximately 6 to 1, or considerably more than the 4·5 to 1 value which was originally planned, and which would have given an optimum performance with the regenerator.

It is felt that the value of a regenerator for locomotive service with low cost fuels is largely dependent upon reducing the first cost and maintenance cost of the regenerator to a very low figure. The performance of the plant with the regenerator had been determined during the 750-hour test. It was now considered advisable to see how the plant would operate without a regenerator in order to allow an intelligent evaluation of the usefulness of a regenerator in railway practice.

Mr. John I. Yellott and Mr. Peter R. Broadley, as the director and assistant director of research, respectively, of the Locomotive Development Committee, have been responsible for the work described in this article.

Industrial and Labour Notes

Trades Union Congress

This week the eighty-sixth annual Trades Union Congress is being held at Brighton. It began on Monday morning with an address by the chairman, Mr. Jack Tanner, who was until recently the president of the Amalgamated Engineering Union.

In the course of his address, Mr. Tanner recalled that in the years before the war the main concern of the trade union movement was the reduction of unemployment and the attainment of job security. He went on to say that " one of the facts needing constant repetition " was that in a state of full employment higher living standards could be achieved only through greater individual output. It should not be forgotten, Mr. Tanner commented, that higher productivity, like full employment, was a means to an end, and that the end which trade unions had in sight in concerning themselves about increasing industrial efficiency was, all the time, the material well-being of their members. Mr. Tanner then spoke of some of the problems facing trade unions. Among them, he said, were human problems which had a direct impact upon members of trade unions, affecting their jobs, their earning capacity, and the status and prestige of workers generally. Higher industrial efficiency, he considered, certainly meant changes in established customs and ways of working and living. That, Mr. Tanner claimed, emphasised the need for a strong, well-informed trade union movement dealing with industry's problems as they arose through effective consultative and negotiating machinery. There were other aspects of the industrial situation, Mr. Tanner continued, which concerned trade unionists. One of them was the importance of industrial research in developing new products, materials and processes in order to maintain and improve Britain's position in world markets. Linked with that was the necessity to overcome the shortage of scientists and technologists in British industry and to remedy the serious deficiencies in teaching and training facilities. This country, Mr. Tanner commented, did not spend nearly as much on research as other countries which had far less difficult problems of export trade. Then, too, in this country there was a much lower rate of capital investment than was the case either in the U.S.A. or in Germany. Both were this country's competitors in many markets. This lower rate of capital investment could have quite serious and multiplying adverse effects upon our competitive position. These could be seen, Mr. Tanner asserted, in the transport difficulties and consequent high costs resulting from the lack of development of our railways, roads, bridges, waterways and harbours.

Mr. Tanner ended his address by saying that much remained to be done to achieve the degree and quality of joint consultation without which maximum efficiency in the use of men, machines and materials could not be reached. No form of industrial democracy would ever be effective, he suggested, unless it embraced every individual worker, the highly trained technician, the skilled craftsman, the clerical worker, the operator of the simplest machine, and the manual worker.

Coal Consumption

In an article dealing with fuel economy in industry and with the work of the National Industrial Fuel Efficiency Service, *Bulletin for Industry* (published by the Treasury) emphasises the fact that coal consumption in this country is rising more quickly than coal production. From January to August of this year, it is stated, 4,500,000 tons more coal were burnt in the United Kingdom than in the corresponding period of last year, an increase of 3½ per cent. The two main reasons for this increase were colder weather and rising industrial production. The second reason, of course, has the more important implications. Coal consumption in the first eight months of this year was 4 per cent greater than in the comparable period of last year, and consumption by gas and electricity undertakings was up by 1½ and 8 per cent, respectively. The latest statistics from the Ministry of Fuel and Power show that in the thirty-five weeks of this year, ended last Saturday, coal production, at 149,061,900 tons, was just under 2,000,000 tons in excess of the output in the comparable period of last year. Distributed coal stocks on August 28th totalled 14,943,000 tons, compared with 15,380,000 tons on the corresponding date of last year.

Weekly Earnings of Manual Workers

Twice a year, the Ministry of Labour makes an inquiry to ascertain the average weekly earnings of manual wage-earners in the manufacturing industries and certain of the non-manufacturing industries of the United Kingdom. The last such inquiry related to the last pay week in April and covered approximately 6,500,000 workers.

The Ministry has issued some provisional figures resulting from this inquiry. These figures show that the average weekly earnings of all manual workers in the industries covered, inclusive of bonuses and overtime and before deduction of income tax or insurance contributions, amounted to £8 6s. 6d., which compares with an average of £8 0s. 1d. in October, 1953, and £2 13s. 3d. in October, 1938. The increase between October, 1953, and April last was thus 4 per cent, and between October, 1938, and last April, 213 per cent. The average hours worked by all manual workers in the last pay week of April were 46·5, compared with 46·3 in October, 1953 and 46·5 in October, 1938. For men of twenty-one and over the average earnings in the last week of April, in all the industries covered by the inquiry, were £9 17s. 8d., compared with £9 9s. 2d. in October, 1953 and £3 9s. in October, 1938, the average hours worked being 48·3, 47·9 and 47·7 respectively. Considering the manufacturing industries only, the average earnings of all manual workers rose from £7 19s. 4d. in October, 1953, to £8 5s. 5d. in the last week of April, the average earnings of men in those industries increasing from £9 16s. 7d. to £10 5s. 2d.

The Ministry of Labour says that, expressed as an index (April, 1947=100), the average level of earnings of all manual workers in the industries investigated rose from 155 in October, 1953, to 161 in April last. The index of weekly earnings of men rose in the same period from 153 to 160.

Shift Work

The Institute of Personnel Management has published a booklet, entitled *Shift Work*, which has been prepared by Mr. F. P. Cook. It presents a general survey of the many considerations which affect the application of shift systems in industry. For the preparation of the booklet the author obtained information from thirty-eight leading industrial concerns, and that information has been summarised in sections dealing with shift systems, personnel administration, hours of work, and " inconvenience " payments. Other sections of the survey deal with such matters as the economic, legal and social aspects of shift working.

In the conclusions reached by this survey, the author of the booklet points out that the economic advantages of shift work are greatest where capital charges and overheads are high in relation to labour costs. He says also that one of the temptations of these complicated times is that of excessive simplification, typified by the search for the single solution. The extension of shift work, the booklet comments, will not alone revive the fortunes of a nation or a concern, but in the right circumstances it can help.

The booklet can be obtained from the Institute of Personnel Management, Management House, Hill Street, London, W.1, price 4s.

Employment and Unemployment

A report by the Ministry of Labour on the employment situation in Great Britain at the end of July says that there were 22,515,000 (14,968,000 men and 7,547,000 women) in civil employment. This figure was 50,000 higher than that returned at the end of June. In the twelve-week period ended July 28th, the employment exchanges filled 691,000 vacancies, compared with 678,000 in the corresponding period of last year, and at the end of July there were 383,000 vacancies which had been notified to the exchanges but were still unfilled.

In the country's basic industries there were 4,028,000 people at work in July. This was 10,000 more than in the preceding month, but the increase was a seasonal one, as the principal addition was to the agricultural labour force. In the manufacturing industries there was a net increase of 19,000 in the labour force during July, bringing the total by the end of the month to 9,028,000. In these industries the " engineering, metal goods and precision instruments " group took on 2000 more people, making the total number employed 2,635,000, compared with 2,547,000 a year earlier. In other industries and services the principal additions were in distributive trades and professional, financial and miscellaneous occupations. There was no change during July in the number employed in building and contracting, which remained at 1,422,000, or 8000 below the number employed a year ago.

About unemployment, the Ministry of Labour's report says that on August 9th the number of people registered as out of work was 239,600, compared with 220,133 registered on July 12th. The increase of 19,500 is considered to have been almost entirely due to the registration of young people leaving school at the end of the summer term.

Productivity Reports

The last of the productivity teams' reports, that dealing with " Industrial Engineering," has been published this week and is reviewed on another page of this issue. Concurrently with the publication of this report, the British Productivity Council has issued some interesting particulars about the work of the Anglo-American Council on Productivity. The Anglo-American Council, it will be recalled, was formed in 1948 " to find means whereby the technical knowledge and experience which lies behind high productivity in the U.S.A. could be placed at the disposal of British industry." The membership of the Council consisted of representatives of management and labour in the United Kingdom and the U.S.A.

During the four years of its existence the Anglo-American Council on Productivity sponsored the visits of sixty-seven teams to the U.S.A., and seventy-two reports on specific industries and specialised technologies have been published. In all, 911 people took part in the tours made by the teams, during which 2000 industrial establishments were visited. In general, a team consisted of about fifteen members and the visits lasted for six weeks. Most of the important industries were examined, and certain of the teams studied techniques applicable to many industries, such as materials handling, production control and plant maintenance. In their subsequent reports the teams made various recommendations, and steps have been taken to encourage the adoption of these recommendations in the industries of this country.

By the time the Anglo-American Council on Productivity was dissolved in the autumn of 1952 it was generally acknowledged that a joint management and trade union approach to the task of raising productivity was not only desirable but practical and effective. Moreover, the experiences of the specialist teams indicated clearly that knowledge of industrial methods and techniques was not confined to the U.S.A. and that there was in fact no lack of it in this country. The main problem was to encourage the wider dissemination of knowledge concerning the best industrial practice. It was considerations of this nature which led to the establishment of the British Productivity Council in order that the " follow-up " activities of the Anglo-American Council on Productivity might be continued.

Notes and Memoranda

Rail and Road

INTERNATIONAL MOTOR INDUSTRY CONFERENCE.—The president of the Institution of the Motor Industry, Mr. S. S. Dawes, is leading a British delegation at the fifth International Technical Congress of the Motor Industry, which begins at Munich on Monday next, September 13th. The following papers are to be presented at the congress by members of this delegation :—" The Trend in the Development of Servo Motors for Motor Car Brakes," by Mr. S. H. Edge ; " The Role of Tyres in Automobile Design and Performance," by Mr. T. French ; " Driving Control and its Simplification," by Mr. W. Ray Turner ; and " British Automotive Diesel Engines for Light Vehicles," by Mr. A. W. Gosling.

FRENCH RAILWAYS' ELECTRIFICATION IN UPPER SAVOY.—A further stage of the French Railways' programme of electrification of lines in Upper Savoy from Aix-les-Bains with 25kV at 50 c/s has recently been completed by the introduction of electric traction between La Roche-sur-Foron and Annemasse, 3 miles from Geneva. The contact voltage on the section from Aix-les-Bains to La Roche-sur-Foron, originally fixed at 20kV, has now been raised to 25kV, which is the voltage approved for general adoption by the International Union of Railways. Electrification of the La Roche-sur-Foron-Bonneville section is due to be completed by March, 1955, and of the Bonneville-St.-Gervais-les-Bains-Le Fayet section in 1956. The line from Paris to St.-Gervais and Chamonix will then be electrified throughout.

Air and Water

" EMPRESS OF CANADA."—The burnt-out hulk of the former Canadian Pacific liner " Empress of Canada," which has been bought by Italian scrap merchants, set out from the Gladstone Dock, Liverpool, for Spezia on Wednesday, September 1st, under tow by the Dutch tug " Swarte Zee."

FAST REPLENISHMENT TANKER.—The fast replenishment tanker " Tide Austral," which has a length overall of 583ft, a length between perpendiculars of 550ft, a beam of 71ft, and a deadweight of 17,700 tons, has been launched from the Musgrave yard, Belfast, of Harland and Wolff, Ltd.

TURBO JET ENGINES FOR VERTICAL LIFT.—The Minister of Supply, Mr. Duncan Sandys, referred this week to the development of a test rig capable of vertical flight from the thrust of turbo jet engines suitably mounted. On this wingless tubular rig are mounted two Rolls-Royce " Nene " engines with their jet effluent directed downwards through baffles and by which the thrust angle can be adjusted. The pilot sits in the normal horizontal position. Both tethered and free ascents have been made. Later developments of this rig have not been disclosed.

COLLEGE OF AERONAUTICS.—The award of the Perring scholarship for the two-year course at the College of Aeronautics, Cranfield, which begins in October, has been made to Mr. G. E. Smith, of Palmers Green, London, N.13. Mr. Smith graduated at the Imperial College of Science and Technology, where he gained a first-class honours degree in civil engineering. The College of Aeronautics also announces the award of the English Electric Research Fellowship in Aeronautics to Mr. M. E. Filby, of Brockworth, Gloucester. Mr. Filby is on the research staff of Gloster Aircraft Company, Ltd.

Miscellanea

MARCHWOOD POWER STATION.—The ceremony of laying the foundation stone of the Marchwood power station, Hants, was performed on Wednesday, September 8th, by the Lord Lieutenant of Hampshire, the Duke of Wellington, K.G. Work on the site was started in August, 1952. The first 60MW turbo-alternator is due to be commissioned in the autumn of 1955. An ultimate generating capacity of 480MW is envisaged.

OIL CONSUMPTION.—According to statistics published by the Petroleum Information Bureau, the total consumption of oil in Great Britain for the first half of this year, excluding bunker fuel deliveries, was 10,287,252 tons, representing an increase of over 10 per cent compared with 1953. The total includes motor spirit 2,811,280 tons, kerosene 715,135 tons, Derv. fuel 671,304 tons, gas, diesel and fuel oils 3,213,377 tons, refinery consumption 932,019 tons, lubricating oils 421,805 tons, and bitumen 401,699 tons.

INAUGURATION OF TRACTION REPAIR FACTORY AT BELO HORIZONTE, BRAZIL.—The first building of the Belo Horizonte factory of Metrovick do Brasil (Electricidade) Limitada, a subsidiary of Metropolitan-Vickers Electrical Company, Ltd., was officially opened on August 4th, by Dr. Juscelino Kubitschek, Governor of the State of Minas Gerais. The main purpose of the new factory is to carry out heavy maintenance work for the Central Railway of Brazil and the Rede Mineira de Viaçao, and for other electrified lines in Brazil.

DEVELOPMENTS IN ELECTRO-CHEMISTRY.—The University of Liverpool states that a post-graduate course of twenty lectures on " Modern Developments in Electro-Chemistry " will be given on Friday evenings at 6 p.m., beginning on October 8th, in the Muspratt Lecture Theatre, Brownlow Street, Liverpool. The course, the fee for which is £4 4s., is intended for graduates in chemistry, metallurgy or engineering and persons of comparable qualifications working in those fields. The course will be conducted by Dr. A. Hickling, reader in physical chemistry at Liverpool University.

INSTITUTE OF METALS.—The Institute of Metals announces a special general meeting on Thursday and Friday, November 25th and 26th, for the benefit of those who were unable to participate in the autumn meeting in Switzerland. The meeting will be held at the Institute's headquarters at 4, Grosvenor Gardens, London, S.W.1, beginning at 2.30 p.m. on November 25th with a session on " The Constitution of Titanium Alloys." At 10 a.m. on the morning of November 26th there is to be a discussion on " Preferred Orientation," and at the concluding session, beginning at 2.30 p.m., the subject for discussion will be " Corrosion and Staining of Aluminium Alloys." The discussions at each session will be based on papers already published in the Institute's *Journal*.

MATERIALS HANDLING CONFERENCE.—The materials handling sub-committee of the Institution of Production Engineers is arranging a one-day conference on methods used for handling materials, with particular reference to the requirements of smaller firms. This conference will be held on October 23rd, beginning at 9.30 a.m., at the works of John Wright and Co. (Radiation), Ltd., Birmingham, the main theme being " to the factory, through the factory, and out of the factory." The programme will consist of a morning session devoted to a tour of the works, and an afternoon session of lectures and discussion. In conjunction with the conference, there is to be a small exhibition showing various methods of handling applicable to certain industries. Full details of the conference may be obtained from the Institution of Production Engineers, 10, Chesterfield Street, London, W.1.

SOUTH DEVON TELEVISION STATION.—Following the consent given by the Minister of Agriculture to the construction of a television and sound broadcasting station at North Hessary Tor, Dartmoor, the B.B.C. proposes to proceed immediately with the construction of a permanent television and V.H.F. transmitting station which will include a 750ft mast. It is hoped that the television station can be completed by the end of 1955 and the V.H.F. station during 1956. The B.B.C. says that, in order to bring television to this area at an earlier date, it intends to install at North Hessary Tor a temporary station which will consist of a low-power mobile transmitter and a 150ft mast. The coverage of the temporary station will be very much less than that of the permanent one because of the lower power and reduced mast height, but it should provide a satisfactory service in Plymouth and in most places lying within a radius of 15 to 20 miles of the city.

SUPERHEATERS.—A booklet entitled " Sectional Superheaters " is being issued by Bolton's Superheater and Pipe Works, Ltd., Stockport. The effect of superheat is, of course, to increase the total heat per lb of steam by raising the temperature but leaving the pressure constant. This being so, superheaters can be installed in almost any plant without major modifications (except that cast iron fittings must be replaced by steel for temperatures above 450 deg. Fah.). Overall thermal efficiency is increased by improving the efficiency of steam generation, transmission and conversion into mechanical energy. Even in process heating, where at the point of application the steam must be saturated, the correct amount of superheat is beneficial by reducing the transmission loss. These points are discussed in the booklet in non-technical language, and figures are quoted which show that even in plants of very modest size impressive savings are possible.

MEDWAY COLLEGE OF TECHNOLOGY.—New buildings for the Medway College of Technology at Fort Horsted, on the Chatham/Rochester boundary, will be brought fully into use for the first time on September 14th. The extension is on a 7½-acre site, the buildings being originally intended for a Ministry of Labour training centre for craftsmen. Including conversion and installation of new equipment, the cost has been some £500,000. The Medway College of Technology is a regional college and as such will serve not only the Medway Towns, but will be a centre of advanced work for a wider area. With its well-equipped workshops and laboratories, it offers degree courses in mechanical, civil and electrical engineering (including radio engineering), and in chemistry, physics and zoology, in addition to industrial and trade courses in the departments of engineering, science, commerce and building. It has accommodation for about 200 full-time students, 1400 part-time day students, and 4000 evening students.

AUTORADIOGRAPHY COURSE AT HARWELL.—The United Kingdom Atomic Energy Authority states that a special course on autoradiographic techniques, lasting for four days, will be held in the Isotope School, Harwell from December 13th to 16th, under the direction of Dr. S. R. Pelc of Hammersmith Hospital. The course will comprise lectures, demonstrations and practical work. Lectures are to be given on the theory of the photographic process ; photographic action of electrons ; estimation of radiation damage ; calculation of concentration of tracer necessary to produce autoradiographs ; biological results of investigations using autoradiographic techniques, and design of autoradiographic experiments. The demonstrations will include the squashing technique applied to bean roots grown in P.32, stripping film technique, autoradiographic using stripping film technique, and the use of the phase contrast microscope. Practical work will include squash preparations for autoradiography, e.g. bean root ; autographs of sectioned material using stripping film technique ; and processing and staining of autoradiographs using normal and phase-contrast microscopes. The fee for the course is £8 and applications should be made to the Isotope School, A.E.R.E., Harwell, near Didcot, Berkshire.

SAND YACHT.—The advent of the motor-car was the main cause of sand yachts, which were known in 1895 and were mainly of timber construction, falling into disuse. Recently there has been a revival in the sport of sand yachting, and last year Mr. Millett Denning built a yacht which was constructed mainly of light alloys. The yacht weighed 7 cwt unladen and with a sail area of 246 square feet attained a speed of 50 miles per hour. A second yacht, " Coronation Year Mark II," has been developed from the earlier model, and has a length of 26ft, a width of 16ft, a height of 30ft and a sail area of 286 square feet. This new yacht, constructed mainly of light alloys, including " Duralumin " supplied by James Booth and Co., Ltd., weighs 9 cwt unladen, and incorporates an arrangement at the mast head specially designed to avoid undue stress in the gaff boom when the cotton mainsail is filled. Assembly of the yacht is by wing nuts and couplings so that it can be dismantled for easy transport. Speeds of 75 miles per hour are expected and with a two-man crew an attempt is to be made to establish a British native speed record over the flying mile under the rules of the Fylde International Sand Yacht Club, which has been formed at Lytham St. Annes.

Contracts

WOODALL-DUCKHAM CONSTRUCTION COMPANY, Ltd., 63–77, Brompton Road, London, S.W.3, has received the order for the new coke oven plant to be built at Ravenscraig, near Motherwell, by Colvilles, Ltd., as part of a £20,000,000 steel development scheme. The installation, which will cost about £2,500,000, is to carbonise 1600 tons of coal per day and will comprise seventy W.-D. Becker coke ovens, coal handling, storage and blending plant, coke handling and screening plant, by-products equipment ; benzole recovery and rectification plant and water recirculation and cooling equipment.

DAVY AND UNITED ENGINEERING COMPANY, Ltd., Sheffield, has received the order to build the new blooming mill for the Lackenby works of Dorman Long and Co., Ltd. This mill, a 52in by 112in reversing blooming and slabbing mill, is being designed to roll ingots weighing from 4·4 tons of 23in square section up to 20 tons with a shaped section of 52in by 41in. Its primary purpose will be to produce blooms for subsequent conversion into broad-flange beams, ranging in size from 6in by 4in to 36in by 16½in. It will, however, also roll rectangular or shaped blooms for joists, channels, angles and sheet piling, in addition to slabs up to 50in wide. The mill's output will be of the order of 15,000 tons per week. The blooming mill will be driven by two 4000 h.p. R.M.S. motors (each 12,000 h.p. peak) and will be equipped with universal manipulators and tilting gear, all necessary main and auxiliary roller tables, ingot tilting chair and ingot weighing equipment. A 1350 tons hydraulic open-sided upcutting bloom and slab shear, with pump and accumulator drive and capable of cutting slabs up to 10in by 50in or equivalent section up to a maximum thickness of 19½in, will also be supplied along with approach and run-out tables and a nine-chain transfer bank. The value of the contract is nearly £1,000,000 and the mill is expected to start production in January, 1957.

Personal and Business

MR. A. W. WELTON has been appointed a director of Mullard, Ltd.

MR. B. C. FLEMING-WILLIAMS has been appointed general manager of Sylvania-Thorn Colour Laboratories, Ltd.

MR. J. R. S. HALFORD has been appointed export sales manager of I.T.D., Ltd., 95–99, Ladbroke Grove, London, W.11.

THE GENERAL ELECTRIC COMPANY, Ltd., announces the appointment of Mr. J. S. Langlands as assistant manager for Scotland.

MR. R. R. BADER has been appointed a director of Matthew Hall and Co., Ltd., Matthew Hall House, Dorset Square, London, N.W.1.

DR. T. P. O'SULLIVAN, M.I.C.E., has established a London office at 249, Waldegrave Road, Twickenham, Middlesex (telephone, Popesgrove 2692).

DAVY AND UNITED ENGINEERING COMPANY, Ltd., Sheffield, states that Mr. Clifford Sturdy has been appointed assistant chief engineer (projects).

METWAY ELECTRICAL INDUSTRIES, Ltd., has changed its address to Metway Works, Canning Street, Kemp Town, Brighton, 7 (telephone, Brighton 28366).

THE JOHN THOMPSON GROUP OF COMPANIES is opening a new branch office, on October 1st, at Sunlight House, Quay Street, Manchester, 3 (telephone, Deansgate 6151).

THE BRUSH GROUP, Ltd., will in future trade in Venezuela under the title Brush Group de Venezuela Sociedade Anonima. Mr. C. P. Court has been appointed director and manager.

MR. DONALD MCDONALD, F.R.I.C., who has been chairman of the executive committee of the board of Johnson, Matthey and Co., Ltd., since 1950, has retired after forty-four years' service with the company.

MR. G. H. M. HOUSTON, A.M.I.E.E., has been appointed manager of the power applications branch of Brookhirst Switchgear, Ltd., His address is Universal House, Buckingham Palace Road, London, S.W.1.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., Rugby, announces the retirement of Mr. R. S. Jones, M.I.E.E., manager of the plant sales department, after forty-one years in the company's service. His successor is Mr. R. M. Grant, M.I.E.E.

British Patent Specifications

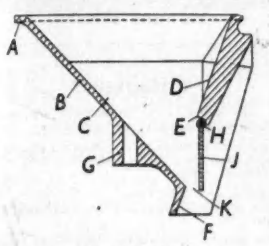
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

FURNACES

713,216. April 8, 1952.—FURNACE GRATES, Federated Foundries, Ltd., and Robert Simpson Silver, both of 75, Hawthorn Street, Glasgow, N.

The improved draught controlling unit for a furnace grate is in the form of a casting having a surrounding rectangular flange *A*, an inclined rear wall *B*, side walls *C*, and a short front wall *D*, which terminates



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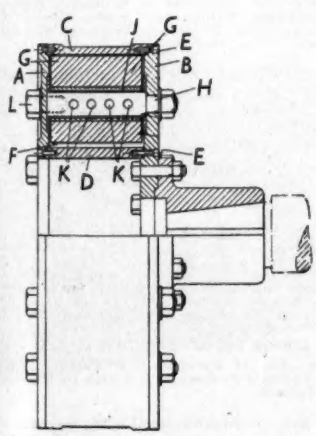
at *E*. The walls form a duct which increases in cross sectional area towards the top or discharge end. The two side walls *C* extend beyond the front wall *D* and are flared outwards. The inclined rear wall, at its lower end, terminates in a short inclined flat face *F*. The rear wall has a boss *G*, through which a bolt can be passed to suspend the draught controlling unit from the grate. Pivotally suspended from the transverse spindle *H* below the front wall *D* is a flap valve *J*, which normally hangs vertically so that its lower edge is below the level of the inclined rear wall. The flap valve closes the opening bounded by the foot of the front wall and the side walls, and there is formed an air inlet opening *K*. In a grate installation the flaps normally hang vertically and air to support combustion enters the openings *K* and passes through the ducts to the grid. The area of the inlet *K* is reduced automatically by an increase of air pressure on the flap valve, which moves inwardly under the pressure of the air. The amount of air passing through the duct is thereby automatically reduced. When the air pressure increases to such an extent that the flap valve is completely closed it shuts against the lower edge of the rear wall *B*. By such improvement there is no danger of ashes or clinker preventing the free swinging movement of the flap valve.—*August* 4, 1954.

POWER TRANSMISSION

712,641. November 23, 1951.—VISCOUS VIBRATION DAMPERS FOR SHAFTS, Ruston and Hornsby, Ltd., Sheaf Ironworks, Waterside South, Lincoln. (*Inventors: James Douglas Thorn and Laurence Frederic Martyn.*)

The invention relates to viscous vibration dampers for damping the torsional oscillations and vibrations in the crankshafts of internal combustion engines. As



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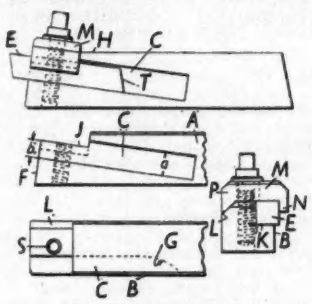
the drawing shows, the damper is housed in a four-part casing consisting of two end walls *A* and *B*, and outer and inner rings *C* and *D*. The end plate *B* is bolted to a hub keyed to the crankshaft. The end plates are attached to the rings by studs *E*. The mass is a heavy flywheel of annular form, which is mounted within the casing in such a way as to leave a clearance *F* between the inside of the mass and the inner ring *D*. The flywheel *G* is attached to the casing by means of six pegs *H*, each having a renewable sleeve *J*, which also provides clearance between the surface of the peg and the sleeve and also at the ends of the sleeve. In the peg four transverse holes *K* are drilled. The outer end of each peg is secured to the plate *A* by a stud and a washer *L*. When assembled the casing is filled by a suitable silicone fluid and is closed by screwed plugs. The fluid fills the free space between the flywheel and the casing and the annular spaces about the pegs. In the specification alternative designs for pegs and their fastenings and the arrangement and number of the transverse holes are also given.—*July* 28, 1954.

TOOLS AND WORKSHOP APPLIANCES

691,375 (Amended). May 19, 1950.—TOOL HOLDERS, James Neill and Co. (Sheffield), Composite Steel Works, Napier Street, Sheffield, 11. (*Inventor: William Leslie Bower.*)

As will be seen from the drawing, the tool holder shank *A* has along one face *B* a slot *C* sufficiently wide to receive the largest size bit *E* to be used. The slot ends at the inner end of the shank in the curve *G*



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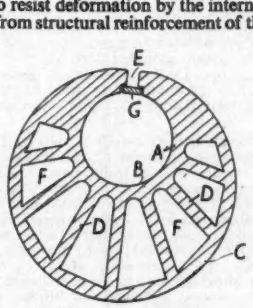
left by the milling cutter. In the top face at right angles to the slotted face is a step *J* with its base parallel to the length of the slot, one side of the slot being removed to leave that end of the slot reduced in width to "*b*" the smallest width of bit to be used in the shank. The slot thus provides a recess with faces *K* to fit two adjacent sides of the bit. At the far side of the shank the edge of the step *J* is bevelled at *L* at an angle of 45 deg. A cramp *M* equal in length to the step *J* has along one edge a stout lip *N* overhanging the slot. At the opposite side the cramp has a lip *P* at an angle of 45 deg. A clearance hole through the cramp receives the set screw which runs in a tapped hole through the step *J*. The clearance hole allows the cramp considerable latitude to fit bits of differing width placed in the recess *C*, the two bevelled surfaces being always in contact. Tightening the cramp on the shank also tightens it transversely whatever the size of the bit. By inclining the slot towards the stepped part of the shank the cutting end of the bit *E* can easily be brought to any required position or height should the holder be used on the front slide rest of a lathe by simply pushing the accessible rear end of the bit in the slot before finally clamping the bit. Modified designs are also shown in the specification.—*August* 4, 1954.

PRIME MOVERS

713,519. July 10, 1950.—RIGID SLOTTED CYLINDER, Brown Brothers and Co., Ltd., Rosebank Ironworks, Edinburgh, 7, and Colin Campbell Mitchell, of 26, Clermiston Road, Edinburgh, 12.

The invention relates to an improved construction of slotted cylinder wherein the requisite section modulus to resist deformation by the internal pressure is derived from structural reinforcement of the cylinder



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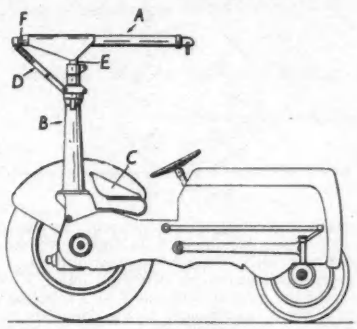
to compensate for the loss of strength caused by the slot. Referring to the drawing, the cylinder shown includes an inner wall *A* surrounding the bore *B*, and an outer wall *C* connected to the inner wall by ribs *D* extending longitudinally of the cylinder. The walls *A* and *C* are eccentric to one another. *E* is the longitudinal slot opening out from the bore. The chambers *F* formed between the ribs may be used for controlling the temperature of the cylinder. A sealing strip *G* is arranged to co-operate with the slot *E*.—*August* 11, 1954.

AGRICULTURAL ENGINEERING

713,244. July 5, 1950.—LOAD LIFTING APPARATUS FOR A TRACTOR, William Hay Smith, Gorostiaga 1540, Buenos Aires, Argentina.

The invention relates to apparatus for mounting on a tractor for lifting loads by which the power of the tractor engine can be employed for lifting and operating appliances. In the construction shown in



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the drawing, a tractor having an installed hydraulic pressure system is provided with a lifting arrangement in the form of a pivoted jib *A* mounted at the top of a telescopic vertical column *B* which is secured to the tractor immediately behind the driver's seat *C*. The jib is pivoted and the end nearest the pivot is tied by the rod *D* to the head of the column *B*. Thus, when the hydraulic pressure system is operated the plunger rod *E* will be driven upwards and will pivot the whole jib about the end tied by the rod. The other end of the jib, including the outer end of the member to which any load is attached, will thus be swung upwards to a height dependent on the distance the plunger rod *E* is raised. By adjusting the telescopic relationship of the members the length of jib can be varied, while the extension bar *F*, in conjunction with the telescopic tie rod *D*, allows the distance of the anchored end of the jib from the head of the plunger rod to be varied as required. The whole jib, with its load, can be swung around through 360 deg. about the vertical axis of the column. In the specification the design and construction of the jib and its supporting column are fully described in connection with the use of various lifting appliances.—*August* 11, 1954.

MARINE ENGINEERING

713,361. January 18, 1952.—ANTI-FOULING MARINE PAINT, John Stanley Cameron and Morton Edward Feiler, whose addresses are 339, West Rosecrans Avenue, Compton, California, and 8584, Sunset Boulevard, Los Angeles, California, U.S.A., respectively.

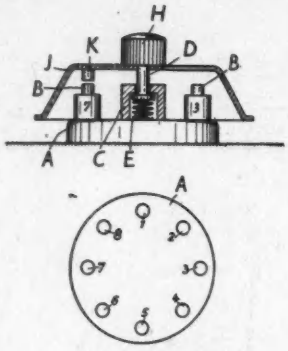
The invention relates to an anti-fouling paint composition for application to the hulls of ships, both to repel marine organisms, such as barnacles, and to prevent permanent adherence of marine vegetable growths. The anti-fouling marine paint has a pigment in the following proportions: 2½ lb of electrolytic copper, 160 mesh; ¾ lb of metallic zinc, 900 mesh; ¼ lb cuprous oxide; ¼ lb mercuric oxide, the pigment being dispersed in a resinous binder comprising 40 per cent chlorinated coal tar pitch by weight, 50 per cent benzol T.S. No. 11 (Shell Oil Company), by weight, and 10 per cent zinc resinate by weight, one part by weight of the pigment being employed to approximately two parts by weight of the resinous binder. Preferably two coats of this growth-repelling composition are recommended.—*August* 11, 1954.

MACHINE TOOLS

713,383. July 17, 1952.—ELECTRIC PRESELECTING SWITCH DEVICES FOR MACHINE TOOLS, Gebr. Boehringer, G.m.b.H., Göppingen/Württ, Germany.

In the electrical control of machine tools frequently the problem arises to effect a selection among a number of circuits with the aid of a manually rotatable preselector and to subsequently close the selected circuit by means of a press button. Referring to the drawing, it will be seen that a circular socket *A* carries eight pairs of contacts 1 to 8 arranged in a circle which are closed by depression of push buttons *B* which are individually co-ordinated to the pairs of contacts. In the centre of the socket *A* is a guiding sleeve *C*, in which a shaft *D* is guided for vertical displacement and is secured against accidental detachment by a head *E* provided on its lower end and engaging beneath a flange *F* at the top of the

sleeve *C*. The head is spring loaded into contact with the flange. A knob *H* and a cap *J* are fixed to the shaft *D*, the cap covering the socket *A* and carrying an actuating finger *K*. Preferably the cap *J* is provided with a pointer, which co-operates with a



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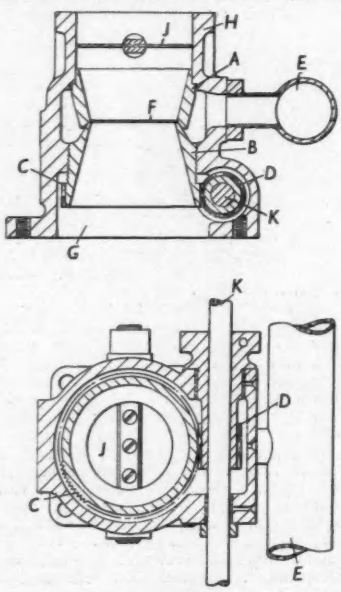
graduation indicating the conditions to be preselected. When the cap is in its upper position the operator may freely rotate it by means of the knob *H* and may thus register the actuating finger *K* with any one of the pairs of contacts 1 to 8 selecting the pair of contacts co-ordinated to the condition to be produced by the establishment of an electrical circuit. When the operator subsequently depresses the knob the cap is lowered, causing the actuating finger *K* to engage the selected press button to actuate the associated pair of contacts closing an electrical circuit.—*August* 11, 1954.

INTERNAL COMBUSTION ENGINES

713,331. April 3, 1951.—GOVERNOR VALVES FOR GAS ENGINES, The National Gas and Oil Engine Company, Ltd., Ashton-under-Lyne. (*Inventor : Joseph Jones.*)

The object of the invention is to provide means whereby adjustment of the air to gas ratio may be made whilst the engine is running. As the drawing shows, a fixed venturi choke *A* is provided and an injection nozzle *B*, externally threaded, is furnished with external worm wheel teeth *C* engaged by a hand-operated worm *D*. Gas enters the choke from a



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pipe *E* by way of an annular space *F* formed between the adjacent ends of the nozzle and choke. Air is admitted through a fixed opening *G* in a casing *H* which houses a butterfly valve *J*. The mixture ratio can be changed by turning a control handle on a spindle *K* carrying the worm *D*, which, by means of the worm and wheel, operates the nozzle. By turning the worm spindle the nozzle *B* moves axially to reduce the width of the axial space between the adjacent ends of the nozzle and choke. Conversely, if the gas mixture ratio is too weak, by turning the spindle in the reverse direction this space can be widened, thus increasing the gas supply and enriching the mixture. It is usual to fit one governor valve to single-cylinder engines and small-size multi-cylinder engines, but in the case of large-size multi-cylinder engines it is found better practice to fit one governor valve to each cylinder.—*August* 11, 1954.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

VULCANISED EXTRUDED RUBBER COMPOUNDS AND TUBING

No. 1155 : 1954. Price 2s. 6d.—This standard replaces the War Emergency Pamphlet published in 1944 and the earlier Government Department Specification T.G. 49, on which it was based. The new standard revises and extends the scope of the original T.G. specification and specifies vulcanizates which are primarily intended to meet the requirements of Government departments for many of their ordinary items in the form of tubing, and goods made by extrusion. It covers four white and six black vulcanizates which are classified according to their hardness and gives skeleton compositions, physical tests and examples of typical compositions. In addition, it gives dimensions and tolerances for plain tubing made from these compounds.

MANUFACTURE AND TESTING OF REFRIGERATING CABINETS AND SECTIONAL COLD ROOMS

No. 2501 : 1954 (cabinets : "Reach-in" type) ; No. 2502 : 1954 (cold rooms : "Walk-in" type). Price 3s. each.—It was generally felt that the two standards already issued, No. 922, "Electrical Refrigerators and Food Freezers for Household Use in all Climates," and No. 1691, "Electrical Refrigerators and Food Freezers for Household Use in Temperate Climates," had a very limited application. The two new standards are intended to make provision for larger commercial and industrial refrigerators, viz., cabinets of 12 cubic feet to 100 cubic feet net capacity, and sectional cold rooms of 100 cubic feet to 1500 cubic feet gross capacity. As before, no attempt has been made to recommend standard sizes ; conditions of manufacture and testing have, however, been prescribed, which should ensure a competitive high level of quality.

Launches and Trial Trips

STEPHEN BROWN, collier ; built by Hall, Russell and Co., Ltd., for J. and A. Brown and Abermain Seaham Collieries, Ltd., Sydney, Australia ; length overall 253ft 6in, length between perpendiculars 240ft, breadth moulded 40ft, depth moulded 16ft 9in, deadweight 1800 tons ; two holds, electric deck machinery ; three 60kW diesel-driven generators ; British Polar diesel engine, eight cylinders, 1230 b.h.p. at 240 r.p.m.—Launch, August 24th.

SPENCER NALL, tug ; built by W. J. Yarwood and Sons, Ltd., for the Geelong Harbor Trust Commissioners ; length overall 110ft, length between perpendiculars 104ft, breadth moulded 28ft, depth moulded 13ft 3in, draught aft 12ft 9in, displacement 475 tons, free speed 11·5/12 knots, static pull 16·5 tons ; electric deck machinery, two 60kW diesel-driven generators, one 500 gallons per minute fire pump, one 750 gallons per minute salvage pump ; British-Polar two-stroke diesel engine, 1310 b.h.p. at 300 r.p.m., Modern Wheel Drive "S.L.M." reverse reduction gearbox. Launch, August 25th.

CYGNUS, oil tanker ; built by the Furness Shipbuilding Company, Ltd., for the Sociedad Transoceanica Canopus S.A. ; length overall 525ft 1in, length between perpendiculars 496ft, breadth moulded 67ft 6in, depth moulded 36ft 5in, draught 29ft 1½in, deadweight 16,260 tons ; twenty-seven oil cargo tanks, one main cargo pump room, three 500 tons per hour Duplex steam pumps, one drain pump ; two 60kW steam-driven generators, one 25kW diesel-driven generator ; North Eastern Marine-Doxford, single-acting, two stroke, oil engine, five cylinders 670mm diameter by 2320mm combined stroke, 5500 b.h.p. at 115 r.p.m., two Scotch boilers.—Trial, August 25th.

ORMESBY QUEEN, trawler ; built by John Lewis and Sons, Ltd., for Talisman Trawlers, Ltd. ; length overall 113ft 6in, length between perpendiculars 100ft, breadth moulded 22ft, depth moulded 10ft 9in ; belt-driven trawl winch ; one 15kW diesel-driven generator, one 10kW belt-driven generator ; Crossley Mark H.R.N.6 diesel engine, 440 b.h.p. at 300 r.p.m.—Launch, August 26th.

DISCOVERER, bauxite ore carrier ; built by The Burntisland Shipbuilding Company, Ltd., for the Pan-Ore Steamship Company, Inc. ; length overall 448ft, length between perpendiculars 425ft, breadth moulded 60ft, depth moulded 29ft 6in, draught loaded 20ft 6in, deadweight 8000 tons, speed 12½ knots ; MacGregor sliding steel hatch covers, two holds, electric deck machinery ; one set of double reduction geared turbines by David Rowan and Co., Ltd., 3300 s.h.p. at 112 r.p.m. of propeller, steam supplied at 425 lb per square inch and 750 deg. Fah. by two Babcock and Wilcox water-tube boilers ; two 250kW turbo-generators.—Launch, August 30th.

BRITISH SOVEREIGN, oil tanker ; built at the Barrow yard of Vickers-Armstrongs, Ltd., for the British Tanker Company, Ltd. ; length overall 665ft, length between perpendiculars 630ft, breadth moulded 85ft 6in, depth moulded 46ft 8in, deadweight 32,100 tons, sea speed 14¾ knots ; seven passengers ; thirty cargo oil tanks, one cargo pump room, three 850 tons per hour turbo-driven cargo oil pumps, three stripping pumps, steam deck machinery ; two 600kW turbine-driven alternators, one 150kW diesel-driven alternator, two 50kW motor generators ; one set of double reduction geared Parsons' turbines, two cylinders, service power 12,500 s.h.p. at 112 r.p.m. of propeller, maximum power 13,750 s.h.p. at 116 r.p.m. of propeller ; steam supplied at 450 lb per square inch and 750 deg. Fah. by two Foster Wheeler "D" water-tube boilers.—Launch, August 31st.

NUDDEA, cargo liner ; built by Barclay Curle and Co., Ltd., for the British India Steam Navigation Company, Ltd. ; length 514ft, breadth 67ft, depth to shelter deck 42ft, gross tonnage 10,130, service speed 16½ knots ; six cargo holds, air conditioned ; derrick complement includes twenty to lift 6 tons and 10 tons, one to lift 25 tons, and one to lift 50 tons, electric deck machinery ; four 300kW diesel-driven generators ; one set of Parsons triple expansion turbines with the h.p. turbine driving through double reduction and the i.p. and l.p. turbines driving through single reduction gearing, service power developed at 116 r.p.m. of propeller, steam supplied at 475 lb per square inch and 750 deg. Fah. by two water-wall, water-tube boilers.—Trial, August 31st.

Catalogues

DORMAN AND SMITH, Ltd., Manchester, 5.—Brochure concerning high rupturing capacity cartridge fuses.

BRITISH JEFFREY-DIAMOND, Ltd., Stennard Works, Wakefield, Yorks.—Publication No. 1503, illustrating and describing the P.15 Gum Flinger.

JOHN KIMBELL AND CO., Ltd., 146, Grosvenor Road, Westminster, London, S.W.1.—Illustrated brochure entitled "Machine Tools of Character."

INDUSTRIAL DRIVES, Ltd., 44, Uxbridge Road, Ealing, London, W.5.—Illustrated details of Drice-Elliot and "Sextet" vee belt variable speed drives.

HILGER AND WATTS, Ltd., 98, St. Pancras Way, Camden Road, London, N.W.1.—Brochure CH318/9, illustrating and describing the Uvispex photo-electric spectrophotometer.

AUTOMATIC TELEPHONE AND ELECTRIC COMPANY, Ltd., Strowger House, Arundel Street, London, W.C.2.—Publication R.E.B.105, describing radio and line transmission equipment.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASLIB

Fri. to Mon., Sept. 24th to 27th.—Church House, Westminster, London, S.W.1, 29th Annual Conference.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Sept. 29th.—LONDON SECTION : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Computing Circuits in Flight Simulators," A. E. Cutler, 6.30 p.m.

INCORPORATED PLANT ENGINEERS

Wed., Sept. 15th.—KENT BRANCH : Bull Hotel, Rochester, Kent, "The Causes and Prevention of Steam Plant Scale," W.F. Gerrard, 7 p.m.——WESTERN BRANCH : Grand Hotel, Bristol, "Planning and Reconstruction of Bristol," R. W. Jefford, 7.15 p.m.

INSTITUTE OF MARINE ENGINEERS

Tues., Sept. 28th.—85, Minories, London, E.C.3, Presidential Address, H. A. J. Silley, 5.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Tues., Sept. 14th.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "Current American Practice in Heating, Ventilating and Air Conditioning," John K. M. Pryke, 6 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Sept. 22nd.—GENERAL MEETING: Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, Presidential Address, A. Campbell, 5.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., Sept. 15th.—BIRMINGHAM SECTION : College of Technology, Suffolk Street, Birmingham, 1, "Time, Space and Productivity," A. B. Waring, 7 p.m.

IRON AND STEEL INSTITUTE

Mon. to Thurs., Sept. 13th to 16th.—IRON AND STEEL ENGINEERS GROUP : 26th Meeting, Newcastle upon Tyne : the meeting will be devoted to the presentation and discussion of seven papers on the developments at Consett Works, followed by visits to the works at Consett and Jarrow, and the ore discharge terminal at the Tyne Improvement Commissioners quay.

JUNIOR INSTITUTION OF ENGINEERS

Fri., Sept. 24th.—14, Rochester Row, Westminster, London, S.W.1, "Some of the Problems of Bomber Design," D. Keith-Lucas, 7.30 p.m.

OLD CENTRALIANS

Tues., Sept. 14th.—Chez Auguste Restaurant, 47, Frith Street, London, S.W.1, "Ecology," E. C. Gordon England, 12.45 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., Sept. 30th.—GRADUATES' AND STUDENTS' SECTION : 4, Hamilton Place, London, W.1, "Air-to-Air Photography," Russell Adams, 7.30 p.m.

WOMEN'S ENGINEERING SOCIETY

Thurs., Sept. 23rd.—35, Grosvenor Place, London, S.W.1, "Some Current Aspects of Television," R. W. Addie, 7 p.m.